**Award Number:** W81XWH-10-2-0180

**TITLE: Military Interoperable Digital Hospital Testbed (MIDHT)**

**PRINCIPAL INVESTIGATOR: Richard Wozniak, MD**

**CONTRACTING ORGANIZATION: DLP Conemaugh Memorial Medical Center, LLC**

**Johnstown, PA 15905**

**REPORT DATE: December 2015**

**TYPE OF REPORT:** Final

**PREPARED FOR:** U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

DISTRIBUTION STATEMENT:

☒ Approved for public release; distribution unlimited

The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision unless so designated by other documentation.

# REPORT DOCUMENTATION PAGE

*Form Approved*
*OMB No. 0704-0188*

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. **PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.**

| 1. REPORT DATE *(DD-MM-YYYY)* | 2. REPORT TYPE | 3. DATES COVERED *(From - To)* |
|---|---|---|
| December 2015 | FINAL | 28Sep210 – 27Sep2015 |

**4. TITLE AND SUBTITLE**

Military Interoperable Digital Hospital Testbed (MIDHT)

**5a. CONTRACT NUMBER**
W81XWH-10-2-0180

**5b. GRANT NUMBER**

**5c. PROGRAM ELEMENT NUMBER**

**6. AUTHOR(S)**

Richard Wozniak, John Hargreaves, Lisa Pasierb, Thomas Simunich, Allen Barger

email: rwoznia@conemaugh.org

**5d. PROJECT NUMBER**

**5e. TASK NUMBER**

**5f. WORK UNIT NUMBER**

**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**

DLP Conemaugh Memorial Medical
Center, LLC
1086 Franklin St.
Johnstown, PA 15905

**8. PERFORMING ORGANIZATION REPORT NUMBER**

**9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)**

U.S Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

**10. SPONSOR/MONITOR'S ACRONYM(S)**

**11. SPONSOR/MONITOR'S REPORT NUMBER(S)**

**12. DISTRIBUTION / AVAILABILITY STATEMENT**

Approved for public release; distribution unlimited

**13. SUPPLEMENTARY NOTES**

**14. ABSTRACT**

The MIDHT project implemented and researched health information technologies (HIT) within the Conemaugh Health System, located in southwestern Pennsylvania. Core technologies under investigation included pharmacy robotics, bar code medication administration (BCMA) and health information exchange via the eHealth Exchange. Statement of work was delivered on time and within budget.

Research activities for Arm 1 included an analysis on medication errors, nursing workflow and satisfaction and financial measures. Conemaugh participated in the 14th Virtual Lifetime Electronic Record (VLER) pilot with the Altoona VA Medical Center (Arm 2). The health information exchange architecture utilized the open source CONNECT software with three custom commercial EHR system adapters. Overall, VA users requested and retrieved clinical data more frequently than Conemaugh users with a positive impact on Veteran satisfaction.

**15. SUBJECT TERMS**

Bar Coded Medication Administration(BCMA) Virtual Lifetime Electronic Record (VLER)
Patient Safety Health Information Exchange

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT | b. ABSTRACT | c. THIS PAGE | | | USAMRMC |
| U | U | U | U | 162 | 19b. TELEPHONE NUMBER *(include area code)* |

**Standard Form 298 (Rev. 8-98)**
**Prescribed by ANSI Std. Z39.18**

## Table of Contents

# *Introduction*

The Military Interoperable Digital Hospital Testbed (MIDHT) (Contract #W81XWH-10-2-0180) was a program of research to develop a real-world testbed environment in Southwestern Pennsylvania. The purpose was to research and evaluate Health Information Exchange (HIE) and health information technology (HIT) and services (HITS) that made health information readily available to consumers and providers. Core technologies under investigation included pharmacy robotics and bar code medication administration (BCMA). Concerning information exchange, this ideally allowed for the secure transfer of information between private sector rural providers, federal partners and patients. MIDHT also defined requirements and solutions to optimize healthcare resources for rural communities and identified lessons learned and best practices that benefit both the global MHS environment and stakeholders in the region. The Department of Defense (DoD) and Conemaugh Memorial Medical Center [Conemaugh; alternatively known as the Conemaugh Health System (CHS)], have common requirements for HIE, connecting disparate systems and providers and enabling secure provider-provider and provider-consumer e-communications. Minimal evidence is available on what business, clinical and technical solutions can be used to overcome the lack of specialists, infrastructure and geographical barriers associated with the delivery of care in rural communities.

The following scopes of MIDHT research were performed over a five-year time period (October 2010 – September 2015).

## Arm 1. The Impact of Medication Dispensing/Administration Technology Within a Rural Healthcare System.

***Subtask 1.1 Implement pharmacy robotic technology and bar-coded enabled medication administration (BCMA) in an acute hospital system setting.***

***Subtask 2.1 Research and Analyze the resulting technological impact on medication errors, pharmacists' productivity, nurse satisfactions/workflow and patient satisfaction.***

In order to improve safety and efficiency of medication dispensing and administration, a complementary set of health information technologies have been implemented. A centrally managed pharmacy robotics system was implemented at the tertiary care facility, Memorial (MMC), in 2011. Many of the medications ordered for use on inpatient clinical units are currently dispensed by the Robot Rx® system. Therefore, bar coded medications are now administered (BCMA) at the bed side to patients on many clinical areas at all three system hospitals, accompanied by an electronic medication administration record (eMAR). Research objectives focused on medication errors, provider workflow, provider satisfaction and related financial metrics.

## Arm 2. Health Information Exchange (HIE) via the Nationwide Health Information Network (NHIN).

***Subtask 2.1 Deploy a limited production, NwHIN standards-based HIE focusing on the bi-directional exchange of electronic medical records between CHS and the Military Health System. CHS information to include data domains residing in acute care and ambulatory settings.***

***Subtask 2.2 Provide technical and documentation assistance on DoD-managed Virtual Lifetime Electronic Record (VLER) efforts.***

***Subtask 2.3 Investigate productizing a Patient Consent module using established standards, such as TP20/XACML.***

***Subtask 2.4 Assess and analyze NwHIN-related activities, to include data center performance metrics, physician evaluation and usage of the NHIN Portal, and resulting benefits of HIE with federal participants.***

NHIN, developed by the Office of the National Coordinator for Health Information Technology (ONCHIT), provides a mechanism for previously disconnected systems and exchanges to connect to each other and share health information using nationally recognized interoperability standards, specifications, participation agreements and policies. The ability to share data electronically among organizations will provide a wide range of benefits to citizens, among them: having up-to-date records available at the point of care; enhancing population health screening; and being able to collect case research faster to facilitate disability claims. Rather than individually build the software required to make this possible, the federal agencies collaborated through the Federal Health Architecture (FHA) program to created CONNECT, a single open source solution that can be reused by each agency within its own environment. MIDHT objectives will focus on executing a limited production HIE portal (using) NHIN (standards) for the purpose of standards-based exchange of Military Health System data domains with private sector partners (e.g. Conemaugh). Live patient data will be utilized after a NHIN-production Data Use Agreement and Reciprocal Services Agreement (DURSA) have been executed.

All abbreviations and acronyms used throughout the document are listed in Appendix A.

# *Body*

## Arm 1. The Impact of Medication Dispensing/Administration Technology Within a Rural Healthcare System.

***Subtask 1.1 Implement pharmacy robotic technology and bar-coded enabled medication administration (BCMA) in an acute hospital system setting.***

***Subtask 2.1 Research and Analyze the resulting technological impact on medication errors, pharmacists productivity, nurse satisfactions/workflow and patient satisfaction.***

### 1.1.1 Pharmacy Robotics Implementation

September 30, 2010 – executed contract with McKesson Information Systems for Pharmacy Automation technology, consisting mainly of:

1. RX Robot – automated bar-code driven medication management and dispensing system that can accommodate up to 600 different medications.
2. MedCarousel - automated medication picking station that manages medications not contained in RX Robot.
3. PACMED – packaging system that supplies RX Robot and MedCarousel with bar-coded unit dose medications.
4. ConnectRX database server – single database server that supports integration of RX Robot, MedCarousel, and PacMed technologies and provides single point of interface into overall Conemaugh Health System (CHS) network environment.

November 12, 2010 - Preliminary facility plans provided by McKesson were presented to the Pennsylvania Department of Health Safety Division in Harrisburg. During the review, the Department determined that a full review of complete plans were required before any renovation work could begin. They based this decision on the scope of structural reinforcement changes needed to accommodate the weight of the RX automation equipment in the MMC Pharmacy department. We submitted complete structural, electrical, power and cooling engineering drawings to the Department on January 14, 2011.

Conemaugh contracted with H.F. Lenz Engineering Group to create engineering drawings of facility renovations necessary for installation of Robot-Rx, MedCarousel, and PACMED.

December 20, 2010 – Conducted a conference call with McKesson, Conemaugh, and Care Fusion to review technical requirements of a new HL7 interface between the McKesson's ConnectRX platform that serves the RX automation equipment and the Pyxis dispensing cabinet systems deployed throughout CHS nurse stations. This interface enabled Pyxis cabinets to automatically notify MedCarousel dispensing system (via ConnectRX interface) when medication restockings are required. This degree of automation improved efficiency of Pharmacy operations.

The following tasks were completed in January – March 2011:

- Racked and staged connected to the network in our data center the Connect-Rx server, which controls Pharmacy automation components including the Robot-Rx, MedCarousel and PACMED.

Racked and staged connected to the network the Connect-Rx test server in our data center, which was used for testing purposes.

- Racked and staged connected to the network in our data center the Interface server, which provides interface capabilities between the pharmacy order system and pharmacy automation systems.
- Test workstation in Pharmacy deployed which will allow for testing of the automation products. Support workstation deployed for Connect-Rx in pharmacy, which allows for support of the Connect-Rx server.
- All pharmacy renovation approvals obtained at state and local level. Electrical requirements finalized and installed, including UPS and emergency power. In addition, floor re-enforcement and compressed air system for the Robot has been completed.
- Pyxis interface installed (this is required for Rx automation to communicate with existing automated medication dispensing cabinets located on nurse stations)
- National Drug Codes (NDC) defined in pharmacy information system
- Existing pneumatic tube system re-directed to allow for MedCarousel placement
- Data cabling for equipment and workstations completed

The following tasks were completed in April – June 2011:

- Facility Prep (compressed air, UPS power) – completed April 11, 2011
- MedCarousel – installed April 11, 2011
- Robot/Overwrap Packager – installed April 18, 2011
- PACMED/Singulator – installed April 18, 2011
- Pyxis ADC Interface – installed April 1, 2011
- Data cabling – completed April 19, 2011
- First Data Bank Integration into ConnectRX – completed April 14, 2011
- MedCarousel Core Team attended training in Cranberry, PA: April 6-8, 2011
- PACMED Core Team attended training in Cranberry, PA: April 26-27, 2011
- Robot Core Team attended training in Cranberry, PA: April 28-29, 2011

On Site Training:

MedCarousel Core Team Training - April 19-20, 2011
PACMED / Robot Core Team Training - April 26-29, 2011
PACMED User Support - May 3-5, 2011
Robot Inventory Prep - May 9-11, 2011
Inventory Prep Training - May 10-12, 2011

Acceptance Demonstration:

MedCarousel - April 28, 2011
Robot - May 3, 2011
PACMED – May 3, 2011

During the last quarter of 2011, the robotic automation effort was fully deployed for MMC and Conemaugh Meyersdale Medical Center (MYMC). Fulfill-Rx automated re-ordering training and operational status went live on August 30, 2011. Numerous equipment-related, workflow-related, and training-related issues came to light as more nurse stations came on board with the new process.

Equipment issues were particularly troublesome and created challenges for the pharmacy staff. These issues included the filling speed and location of stat orders, repackager inconsistencies and applicability to certain medications, suction issues with the robotic arm that resulted in dropped (missing) medications, and increased noise levels. Weekly support calls were held and several field adjustments were made by the vendor on both the Robot and MedCarousel.

Performance and uptime improved incrementally during the period. By September 27, 2011, all but a handful of issues remained outstanding. One area of continued concern was the envelope delivery system, or EDS. This is the mechanism whereby the Robot places picked meds into patient-specific cardstock envelopes for transportation to the nursing station. The EDS will sporadically malfunction and cause some medications to miss the envelope. The vendor has improved the process via equipment adjustments, but reliability issues remained.

Unanticipated workflow issues for nursing came to light as the new process was rolled out. One in particular was the continuation of previous habits. The previous decentralized medication distribution model required nursing to pull all patient medications from automated dispensing cabinets (ADCs) located on each nurse station. During the project planning phase, pharmacy decided to leave the medications in the ADCs as a precaution in the event the new centralized distribution process had problems. Pharmacy discovered that nursing was continuing to pull all their medications from the ADC instead of from the envelopes. The correct process is to pull only narcotics from the ADC, since all other medications are to be in the envelope. This resulted in envelopes being returned to the pharmacy full of medications and requiring manual crediting to the patient's account. The issue was exacerbated by the fact that the bar code medication administration (BCMA) process was not yet deployed and nursing did not have the new carts in place to house the medications sent from the pharmacy. Pharmacy addressed the issue by providing additional education to nursing and by removing the scheduled meds from the ADCs so that nursing must use the envelopes. Anecdotal concerns exist from nursing as they need to empty envelopes before placing specific medications into drawers on the mobile medication carts.

A second workflow issue involved hours of pharmacy operation. Under the decentralized model, night-shift was a slow time with minimal activity other than off-hours order processing. This changed in the new Robot-driven centralized workflow model. Pharmacy learned that they need to utilize the midnight shift to perform cart fill so that the envelopes for the next day can be delivered to Nursing in the early morning. This change required a review of staffing so that additional staff is scheduled for the midnight shift.

A final operational issue involved the capacity of the automation system. We have learned that, even with optimization efforts, the combined capacity of the Robot and MedCarousel are not sufficient to meet the needs of Conemaugh operations. A re-budget request is currently being developed to address this issue by adding a second MedCarousel. Project team identified placement location for second MedCarousel cabinet in Pharmacy. Configuration was finalized and facility drawings were drafted. As was required for the initial Pharmacy robotics installation, the facility changes required to support the second MedCarousel required Pennsylvania Department of Health approval before work could begin. Conemaugh contracted with McKesson on September 26, 2012 for the second MedCarousel dispensing system.

Conemaugh finalized the second MedCarousel dispensing system placement in the centralized MMC pharmacy. Conemaugh worked with an outside engineering firm to prepare documents that were submitted to the Pennsylvania Department of Health in January 2013 for approval before physical

accommodation work began. The amount of site work required was much less than with first MedCarousel due to the fact that the second unit was not as tall as the first one and would not protrude through the ceiling. Floor support was the primary required change.

The second MedCarousel implementation was implemented in the pharmacy on April 8, 2013. Conemaugh streamlined the manual pick processing that occurs when a medication is not able to be stocked in the robot. This also has helped reduce the number of open bulk medication bottles and decrease inventory slightly because of increased efficiency. The second MedCarousel has also helped with the picking processes since many of the oral medications are located in the MedCarousel. The barcode system is fully engaged and ensures patient safety each time a medication is removed from the MedCarousel. Technician time is better spent doing other tasks than searching for a missing medication. The second MedCarousel has helped Conemaugh achieve a better work flow pattern in the drug distribution area. The additional MedCarousel has also helped with the ordering and restocking of inventory when it arrives within the department from the manufacturer. With barcode scanning, Conemaugh can ensure that the medication is in its proper place when being restocked. As with the first MedCarousel, PAR levels were setup to help keep inventory levels sufficient to meet patient needs.


**Figure 1. Robot-Rx in MMC Pharmacy.**

Figure 1 illustrates the MMC pharmacy Robot-RX. Please see Appendix B for additional pictures of the pharmacy robotics equipment.

### 1.1.2 Bar Code Medication Administration (BCMA) "Horizon Admin Rx" Implementation

After execution of the contract with McKesson for the Horizon Admin Rx project in late 2010, the following tasks were completed:

- Vendor and internal project managers assigned
- Nursing champions identified to assist in workflow design
- AdminRx project kick-off conference call with vendor conducted on March 14, 2011
- Build training of MIS and pharmacy staff
- Wireless infrastructure assessed, recommendations made
- MIS and pharmacy staff completed Admin Rx on-line education
- Completed Admin Rx System build
- Carelink interface migration for training and QA environments
- McKesson Implementation Team visit to begin bar code verification
- Citrix environment testing
- Development of user training material
- Training schedules completed
- Set-up and tested Admin Rx reports to Horizon Patient Folder
- Table copied from facility 01 to facility 02
- Continued bar code verification
- Device selection finalized and initial equipment order initiated
- End user training completed – 4 hour classroom session with hands-on practice
- Training of Super User Support Team, which consists of 10 nurses loaned to MIS by nursing to assist in the Admin Rx rollout. These 10 nurses received 40 hours of classroom training by MIS project team experts.
- Device configuration and testing

The first Pilot units consisted of Ashman 7, Rose 7 and Cardiac Intensive Care Unit (CICU) and they went live on September 27, 2011.

After the pilot live deployment was successful, the organization completed the following phased Roll-out Schedule in the Fall of 2011 and Winter of 2012. Devices (Rubbermaid carts, wireless scanners) were deployed to nursing units according to the live schedule below. End user classroom Admin Rx training was provided frequently for nursing units. IT staff and nursing Super Users provided 24x7 live support to nursing units as needed.

<u>October 2011</u>
Ashman 8th, 9th and 10th clinical units
Rose 8th, 9th and 10th clinical units
Main 7, Pediatrics and Women Services

<u>November 2011</u>
Good Sam 4th, 5th and 6th clinical units
Behavioral Medicine Good Sam 7th clinical unit

December 2011
Geropsych Good Sam 8th clinical unit
Aloysia Hall Good Sam 8th clinical unit
E Building 4th and 6th clinical units

January – March 2012
Crichton Center
Intensive Care Unit - Ashman 6
Intensive Care Unit - Rose 6

**Figure 2. Rubbermaid Medication Cart.**

BCMA adoption rate for January 2012 was 88% of total medications administered for inpatients at MMC, 87% of February and 86% for March. Adoption rate is defined as the number of medication administrations where all aspects were completed via bar-coding (wristband check, medication barcode,

wristband verification) divided by the total number of medication administrations for the same period. All inpatient units at MMC were live as of the end of January 2012.

Pharmacy and IT staff began meetings with MYMC regarding Admin Rx implementation at their facility. McKesson Domain Expertise Group performed the Post-Live Optimization Assessment at MMC. MYMC build and planning continued, including device assessment and purchasing.

The Post-live optimization assessment was shared with the Clinical Steering Committee. Nursing, Patient Access, Health Information Systems, and IT discussed the need for bar-code labels to be printed on nursing units to facilitate BCMA. Testing of build for the MYMC facility and staff training were started.

MYMC went live with BCMA on April 17, 2012 as planned and achieved a closed-loop BCMA adoption rate of 95% in the first month. This rate was higher than any department at MMC at the current time.

The patient ID label printer Pilot with Ashman 6 Nurse Station was completed in late April and began full deployment in May. All but two of the 22 Nurse Station at MMC was equipped with ID label printers as of June 20, 2012. With these printers in place, Nursing could now locally print replacement bar-code wristband labels when needed. Feedback from Nurse Managers was very positive. The printers have been so popular with Nursing that we are also now using these same printers to print “form labels”. Form labels provide improved legibility vs. imprinting the forms with a physical ID card and Addressograph machine. The IT department successfully implemented the v10.3 version upgrade of AdminRX application and associated Care Organizer application on June 26, 2012.

IT staff collaborated with the Respiratory Department in an effort to address staff complaints regarding difficulty pushing the Rubbermaid medication carts. In contrast to Nursing, workflow at Respiratory requires them to move the carts longer distances and also onto elevators. Beginning May 7, 2012, a differently configured cart consisting of a lithium battery and larger cart wheels was put into Pilot use.

The organization increased the Conemaugh BCMA adoption rate to 96% for September 2012 from 88% in June and 86% in March. The significant improvement was achieved primarily by providing nurse managers with staff-specific performance reports. Nurse Managers used these reports to work with staff whose rates were low to determine the reasons and address them. MYMC maintained their adoption rate at a consistent 94% – 96% range through September.

Conemaugh contracted with McKesson for the Medication Safety Analytics application. McKesson installed the BCMA Analytics feed into the performance management system called Horizon Business Intelligence (HBI). The Decision Support department conducted user training for nurse managers and directors on the use of HBI to interact directly with the BCMA data. This is a very rich analytics tool; and once trained, nurse leaders were able to drill into the data to identify specific staff, nurse stations, and medications that require follow-up and possible re-training. Screenshots located in Appendix C provide a look and feel of the BCMA highlights via HBI and the different customizable view levels (by unit, by med, by staff, etc.). Unfortunately only three nurse managers (Critical Care, OB/GYN and Med – Surg) took the initiative (as of February 19, 2015) to retrieve the data directly from HBI for a grand total of five accesses. Tools and information are only productive if used by people who can impact change.

IT staff worked with leadership of the School of Nursing on device needs for student nurses. Issues included defining locations to house the carts when not in use by the students and whether or not these

carts are to be reserved for the exclusive use by students. Cart storage is a significant issue at Conemaugh where nurse stations are already overly congested. In addition, we are under constant pressure from the State of Pennsylvania to keep hallways clear. Conemaugh staff finalized the School of Nursing device needs for student nurses in November 2012. Additional Rubbermaid medication carts were deployed in December 2012 after receipt from vendor. The primary purpose was to improve student exposure to the current BCMA process and enhance the learning experience.

Under the current process, paper envelopes are delivered to nursing units each day. Nursing then must transfer the medications from the envelopes into the plastic bins housed in the computerized med carts. Unused medications are returned back to the pharmacy in the same envelopes. This process has created extra steps for nursing and thus has been identified as an area of dissatisfaction. Since the envelopes are re-used as a cost saving strategy, the extra handling associated with this process leads to the envelopes becoming damaged. This, in turn, contributes to dispensing malfunctions from the robot. The Pharmacy department has since worked closely with nursing to pilot a new "exchange bin" method of delivering medications to inpatient units. In this workflow, nursing gets patient-identified plastic bins with the robot-filled medications from the current day. These bins are exchanged with bins from the preceding day for the same patient in the med cart. The expected advantages were: 1) Envelopes never leave the pharmacy so they are much less likely to get mis-handled and damaged (saves cost) and 2) Nursing does not have to transfer meds from envelope to bin and then transfer unused meds from bin to envelope (less chance for error). Feedback from the first two pilot units was positive.

BCMA implementation at Conemaugh Miners Medical Center (MIMC) was delayed. System-wide formulary consolidation efforts were required before BCMA can be implemented in a way that can be effectively supported. In May 2013, MIMC pharmacy medication master file was successfully synchronized with that of MMC and MYMC. A single medication master file now serves all three Conemaugh hospitals. This was a multi-month effort that completed a key prerequisite to implementing BCMA at MIMC. As this task was completed, clinical analysts began the order build process. Meetings were held at the MIMC facility with nursing and ancillary staff to design the workflow process. MIS worked with MIMC Nursing Administration to identify super users to facilitate BCMA training and on-site support, similar to the process used for the MMC implementation. MIS recruited the services of several nursing super users to dedicate time to these tasks. BCMA deployment at MIMC was further delayed due to implementation of the McKesson ER12 upgrade. Design work was started in early November. User training occurred in late January/early February, with full LIVE use beginning on February 25, 2014. Adoption rate for the first full month (March 2014) exceeded 96% and has remained strong since then.

The McKesson Pharmacy System v10.1 Upgrade was successfully completed on October 22, 2013 along with other clinicals. The combination of these upgrades provided additional BCMA functionality for nurses, specifically in the area of IV administration. Benefits of the upgrade release were inclusive of the BCMA system at MIMC as well.

MMC pharmacy and nursing finalized their medication exchange cart pilots and identified a workflow process for hospital-wide deployment. The process identified the pharmacy as maintaining the envelopes and then transferring all medications into exchange bins before delivery to nursing each day. This approach optimized the robot usage by allowing the filling process to remain unattended. The Medication Exchange cart system (transfer carts and exchange bins), originally ordered in January 2014, was not deployed into clinical areas until August - September 2014 due to supplier (Rubbermaid) backorder and pricing issues. Configuration and bids were more costly than estimated due to larger transfer carts.

Figure 3 and Figure 4 depict the bar code scanning rate for CHS by each medical center. Reasons for not achieving a 100% compliance rate can been found in the "Lessons Learned" section. The 95% overall average is still very high and supports adoption of the BCMA process by the entire organization. MYMC achieved the same rate as MMC and MIMC had a higher rate than MIMC. Staff at the rural medical centers have fully adopted and supported the BCMA process.

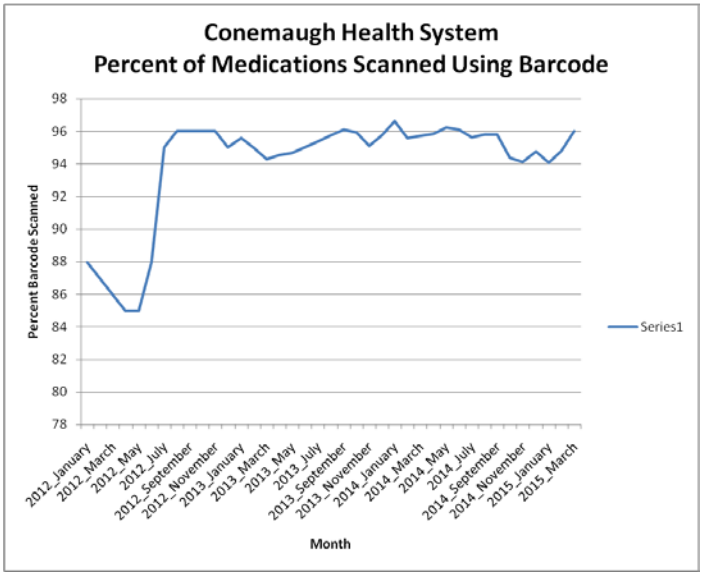



**Figure 3. CHS Medications Scanned Using Barcode.**

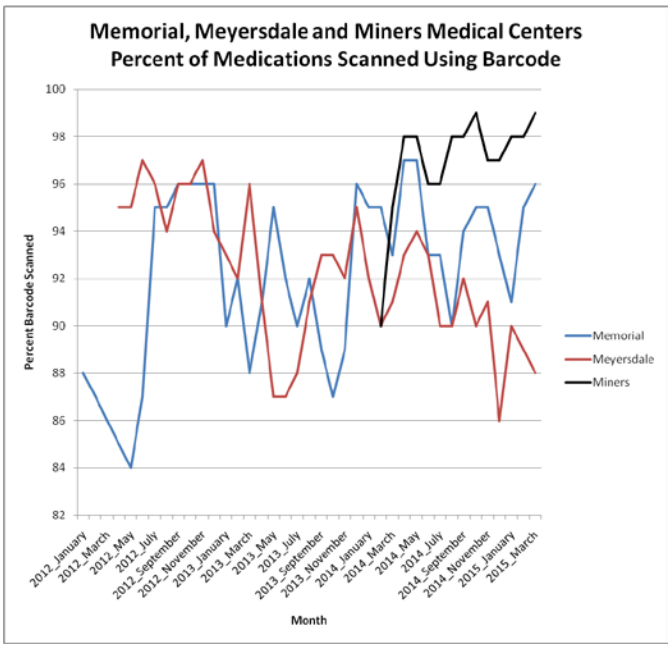



**Figure 4. MMC, MYMC & MIMC Medications Scanned Using Barcode.**

***Subtask 1.2 Research and analyze the resulting technological impact on medication errors, pharmacist productivity, nurse satisfaction/workflow and patient satisfaction.***

Both of the following hypotheses have been rejected:

1. We hypothesize that the implementation of a centralized pharmacy robotic system within the Conemaugh Health System (CHS) will significantly reduce medication expenses and ending inventory, increase pharmacy productivity and reduce the number of nonreturnable expired medications and associated cost.

2. We hypothesize that the implementation of bar code medication administration technology within the Conemaugh Health System (CHS) will significantly reduce the amount of actual medication errors and positively impact provider and patient satisfaction.

### 1.2.1 MMC Pharmacist Productivity

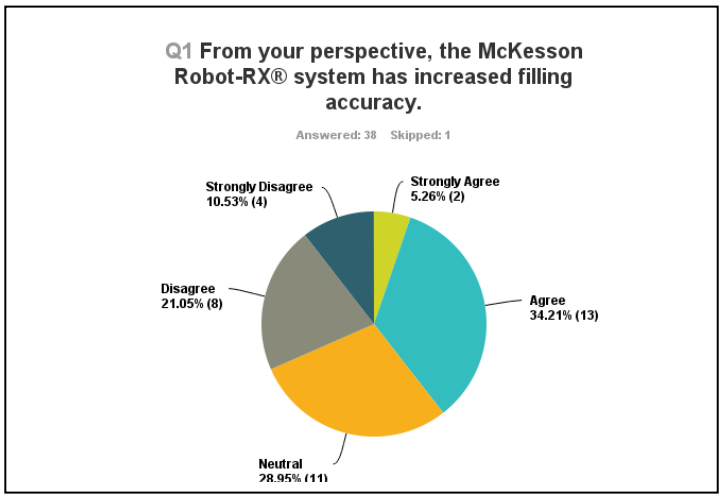
Data contained within the Horizon Meds Manager (HMM) system could not be collected in a consistent and reliable manner across the Pre and Post time periods due to managerial turnover, system upgrades and report formatting changes. The inconsistent and missing data therefore was not suitable for analysis by the research team.

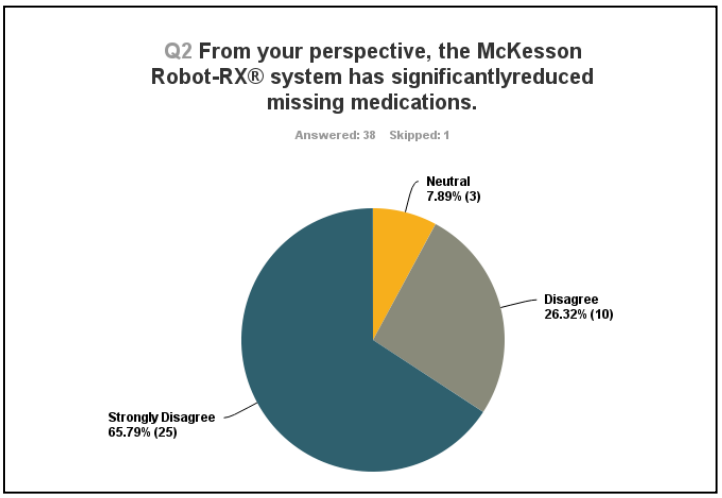
### 1.2.2 MMC Pharmacy Automation/Robotics Dispensing Survey (Pharmacy satisfaction)

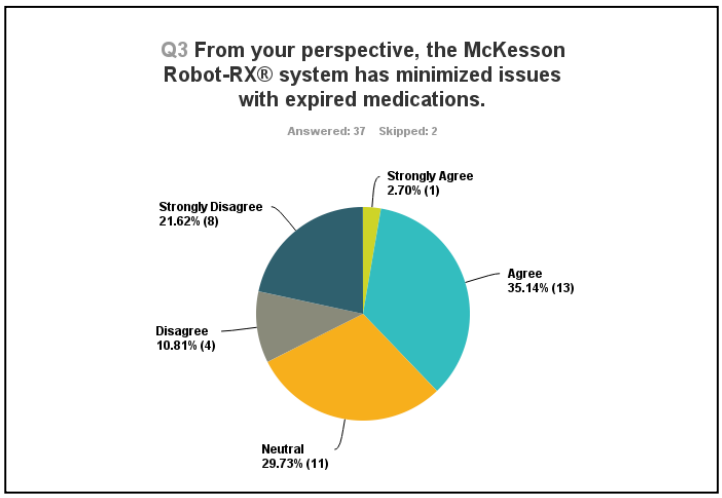
Thirty-eight (38) pharmacists and pharmacy technicians completed the internally developed Pharmacy Survey. Responses were collected from December 2011 through January 2012. The respondents indicated a diversity of years of experience, with 53% indicating greater than 15 years of experience, 26% with 5 or less, and the remaining 21% from 6-15 years. A copy of the survey is included in Appendix D.

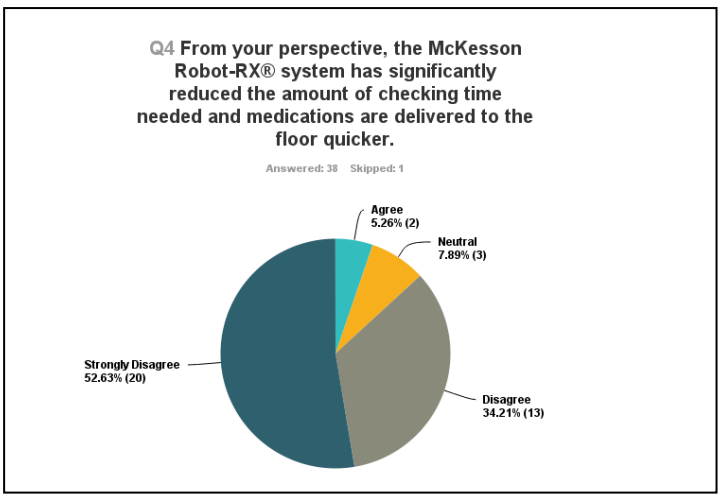
The majority of those surveyed responded favorably. Summary points from the survey are provided below.

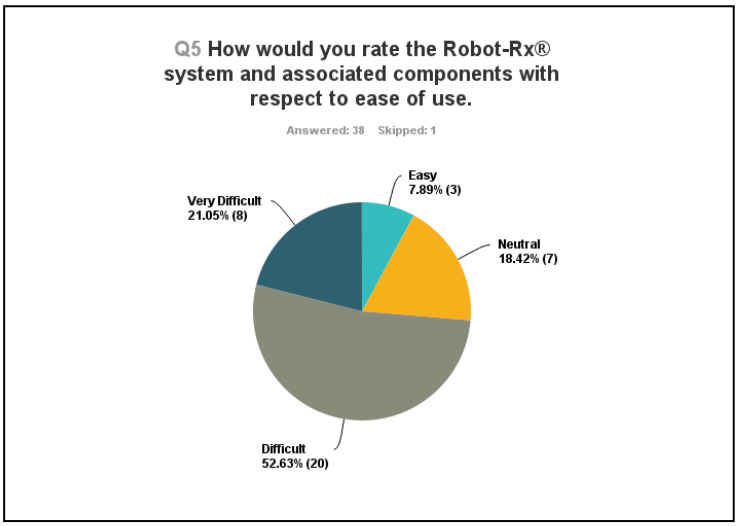
- Nearly 40% of pharmacists and pharmacy technicians indicated they believed the McKesson Robot-RX® system increased filling accuracy. Roughly 30% were neutral however.
- 92% (those who strongly disagreed or disagreed) felt the system had not reduced missing medications.
- The impact of the system on expired medications was nearly evenly distributed. 38% felt expired medications issues were minimized.
- Most (87%) felt checking time and the delivery of medications were not reduced.
- Nearly 75% of respondents rated the Robot-RX® system as difficult or very difficult to use, with the system affecting over 70% of medications.



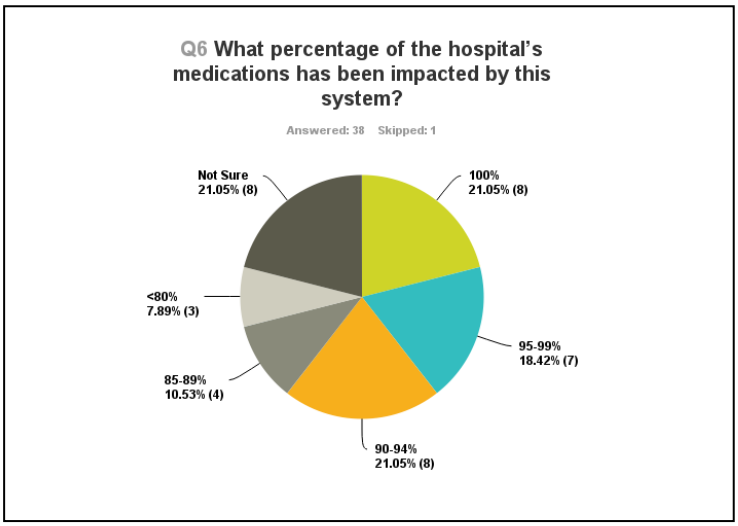




**Figure 5. Pharmacy Survey Questions 1, 2, 3, 4, 5 & 6.**

In the opinion of the pharmacists and pharmacy technicians surveyed, there is now less time available to spend on clinical activities. Over 60% disagreed (or strongly disagreed) that patient safety, as reported via a reduction of "near misses" or reportable was not improved. Eighty percent (80%) would not recommend the system to other hospitals (data not shown).

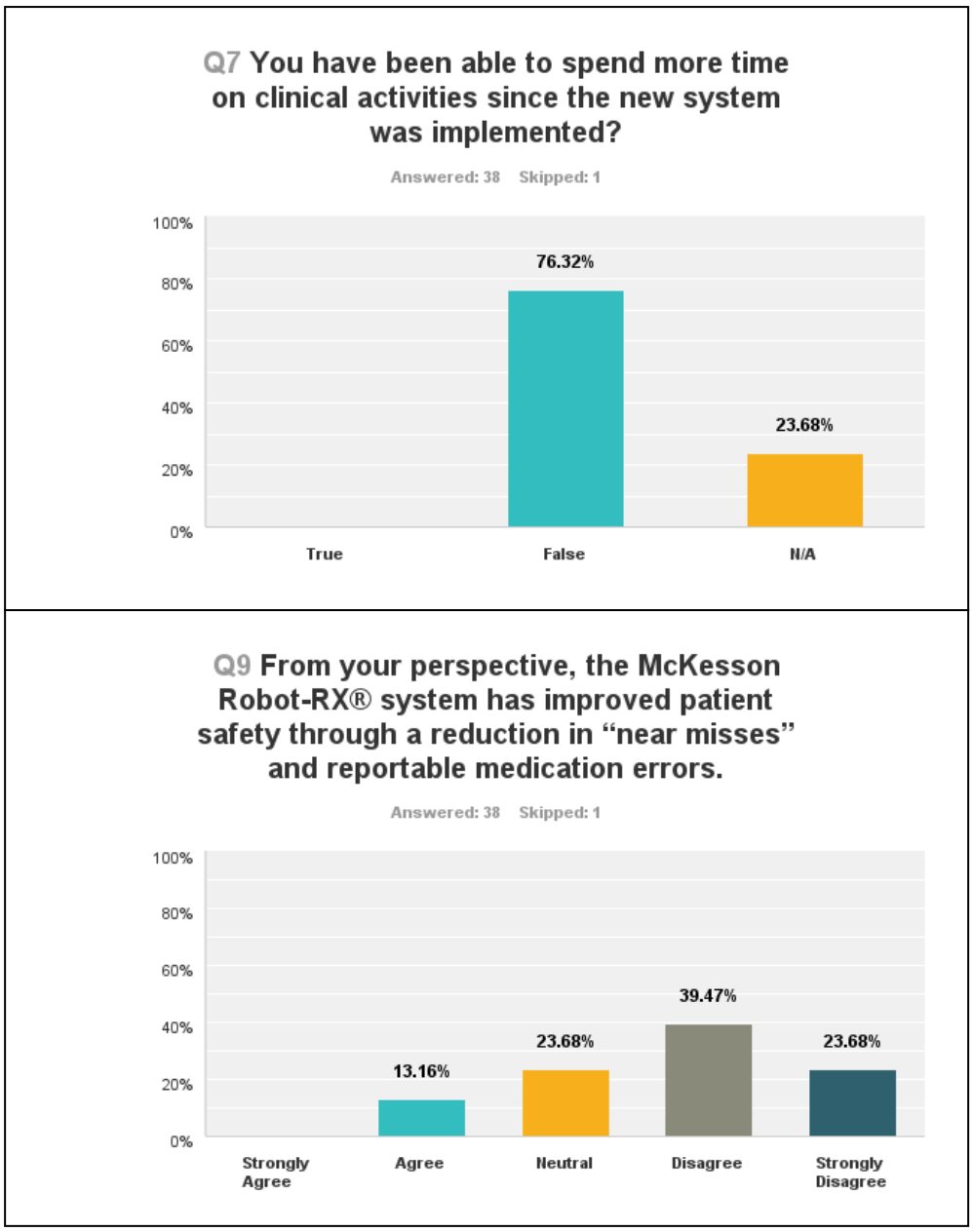



**Figure 6. Pharmacy Survey Questions 7 & 9.**

Additional statistical analyses, chi-square crosstabs by "Would you recommend the system (pharmacy robotics) to other hospitals?" and years of service, were attempted and found to be not tenable due to violations of one of the underlying statistical assumptions, namely, the maximum percentage of cells

with an expected frequency less than five. A non-parametric correlation analyses was also attempted. It too was inconclusive because of violation of the monotonic assumption.

Medication distribution systems have changed significantly during the past decade. In 2011, 63% of hospitals used automated dispensing as the primary method for supplying medications, while 29% used a manual centralized unit dose system. Such usage is a reversed trend from only a few years ago (Pedersen CA 2012). Despite the fact the 50% of hospitals now utilize a BCMA system and another 11% robotic dispensing, the culture of change is not always perceived as favorably despite known benefits to both patient safety and efficiencies. Pharmacy staff at MMC viewed the implemented robotics dispensing system unfavorably, with the majority noting the system was difficult to use and negatively impacted clinical processes. Most failed to note a positive impact on patient safety through a reductions of reportable medication errors and "near misses."

### 1.2.3 Pharmacy Workflow/Time and Motion Study – MMC

The research team conducted time and motion observations of MMC pharmacy both before the implementation of the BCMA system (PRE) and then afterwards (POST). A total of 12 observations were performed during each time period. Varying shifts were selected to create a representative sample. Observations occurred during continuous 4-hour periods.

Data collection was similarly matched between PRE and POST periods including the same day(s)/time(s) of the week and similar time of year (seasonality). Daily patient census was closely matched as well [average census (PRE) = 403, average census (POST) = 463].

*PRE (April 2011)*

12 baseline observations were completed during the month of April 2011. Each pharmacy personnel were shadowed as detailed in Table 1 below.
As depicted below in Figure 7, approximately 27% of the time was used to fill medication orders. The next four most time consuming activities were medication order entry by pharmacists (18%), walking in the department or throughout the hospital (13%), loading medications into Pyxis machines (9%), and talking on the phone to hospital staff (8%).

| Date | Time | Position |
|---|---|---|
| April 11, 2011 | 7:00-11:00 AM | Pharmacist |
| April 12, 2011 | 9:00 PM - 1:00 AM | Pharmacist |
| April 13, 2011 | 8:30 AM-12:30 PM | Technician |
| April 14, 2011 | 2:30 - 6:30 PM | Pharmacist |
| April 15, 2011 | 8:30 AM - 12:30 PM | Technician |
| April 18, 2011 | 7:00-11:00 AM | Technician |
| April 18, 2011 | 12:00 - 4:00 PM | Pharmacist |
| April 20, 2011 | 12:00 - 4:00 PM | Technician |
| April 22, 2011 | 7:00-11:00 AM | Technician |
| April 25, 2011 | 11:00 AM - 3:00 PM | Technician |
| April 26, 2011 | 9:00 PM - 1:00 AM | Technician |
| April 27, 2011 | 3:00 - 7:00 PM | Technician |

**Table 1. Pharmacy Time & Motion Schedule (PRE).**

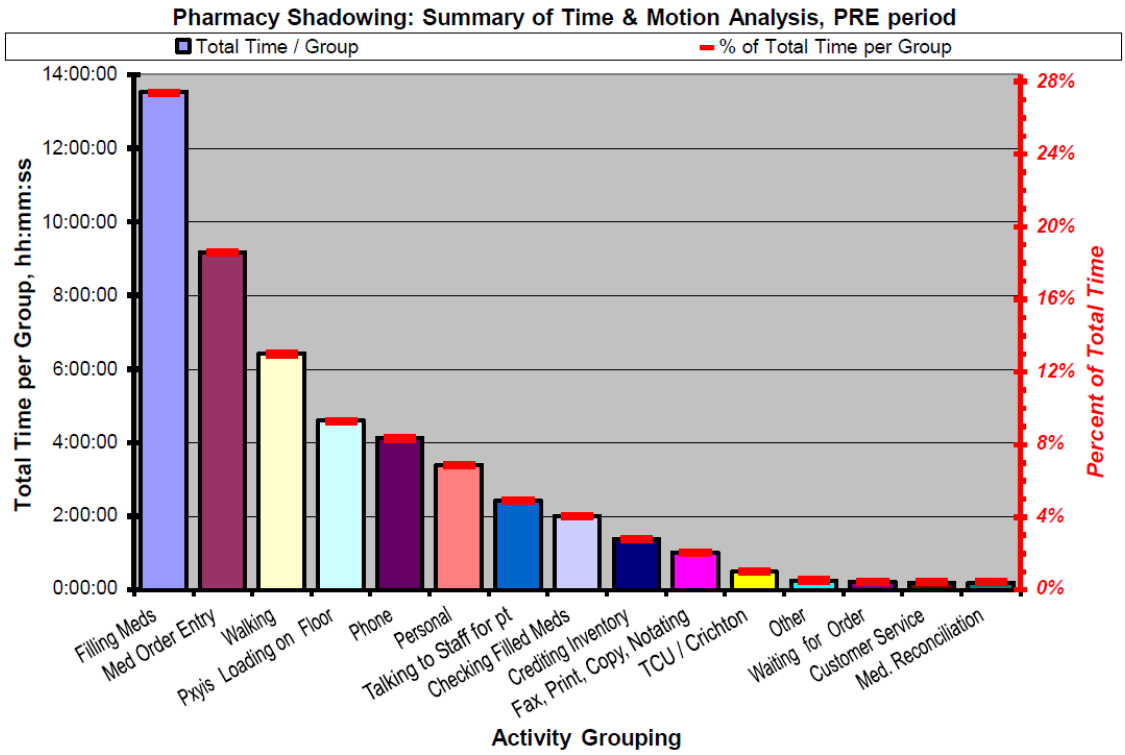



**Figure 7. Pharmacy Shadowing Time & Motion Summary (PRE).**

*POST (April - May 2013)*

Twelve time and motion observations of pharmacy personnel were again conducted post implementation of the pharmacy automation system, after installation of the second MedCarousel and the same time of year. Each pharmacy personnel were again shadowed for a 4-hour period as detailed in Table 2.

| Date | Time | Position |
|---|---|---|
| April 22, 2013 | 7:00 - 11:00 AM | Pharmacist |
| April 23, 2013 | 9:00 PM - 1:00 AM | Pharmacist |
| April 24, 2013 | 8:30 AM - 12:30 PM | Technician |
| April 29, 2013 | 12:00 - 4:00 PM | Pharmacist |
| April 30, 2013 | 9:00 PM - 1:00 AM | Technician |
| May 2, 2013 | 2:30 - 6:30 PM | Pharmacist |
| May 8, 2013 | 10:00 AM - 2:00 PM | Technician |
| May 13, 2013 | 11:00 AM - 3:00 PM | Technician |
| May 15, 2013 | 3:00 - 7:00 PM | Technician |
| May 17, 2013 | 8:30 AM-12:30 PM | Technician |
| May 20, 2013 | 7:00-11:00 AM | Technician |
| May 24, 2013 | 7:00-11:00 AM | Technician |

**Table 2. Pharmacy Time & Motion Schedule (POST).**

As depicted below in Figure 8, approximately 27% of the time was used to fill medication orders, which was the same amount of time that was observed in the PRE time period. The next four most time consuming activities were medication order entry by pharmacists (18%), personal time (13%), loading medications into Pyxis machines (8%), and walking in the department or throughout the hospital (8%).

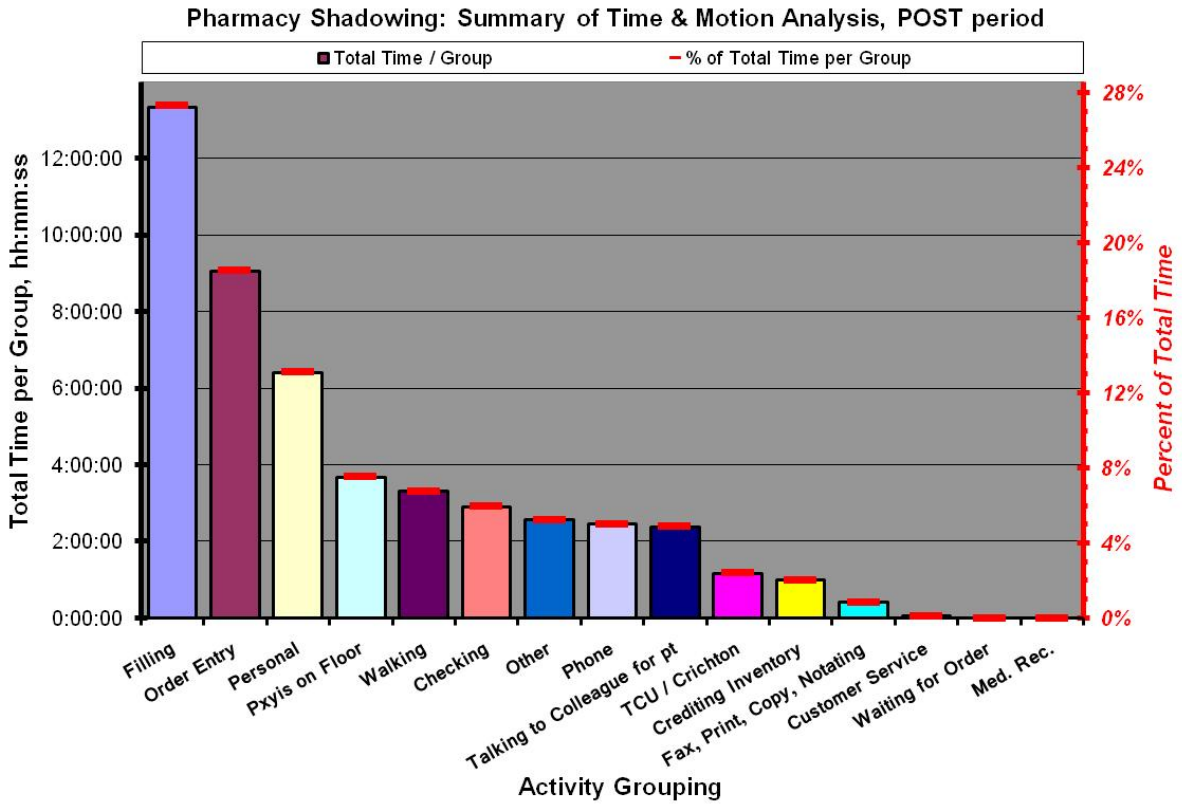



**Figure 8. Pharmacy Shadowing Time & Motion Summary (POST).**

Data was then compared between the PRE and POST periods. Figure 9 and Figure 10 displays descriptive results per process grouping by percentage and total time respectively.

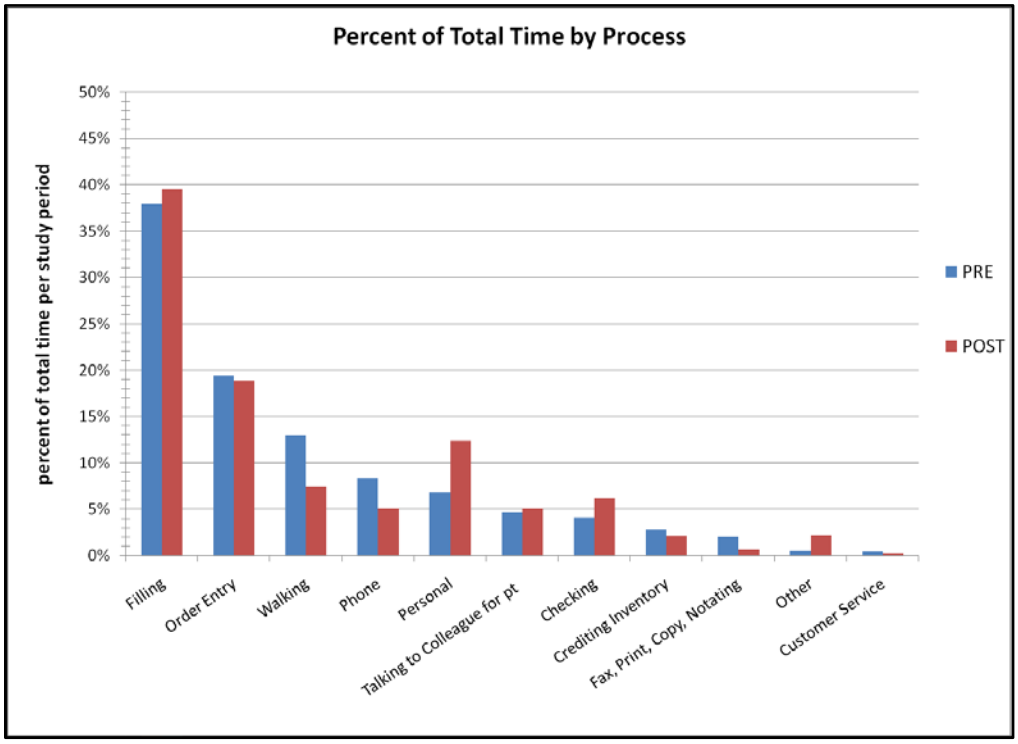



**Figure 9. Percent of Total Time by Process (PRE VS. POST).**

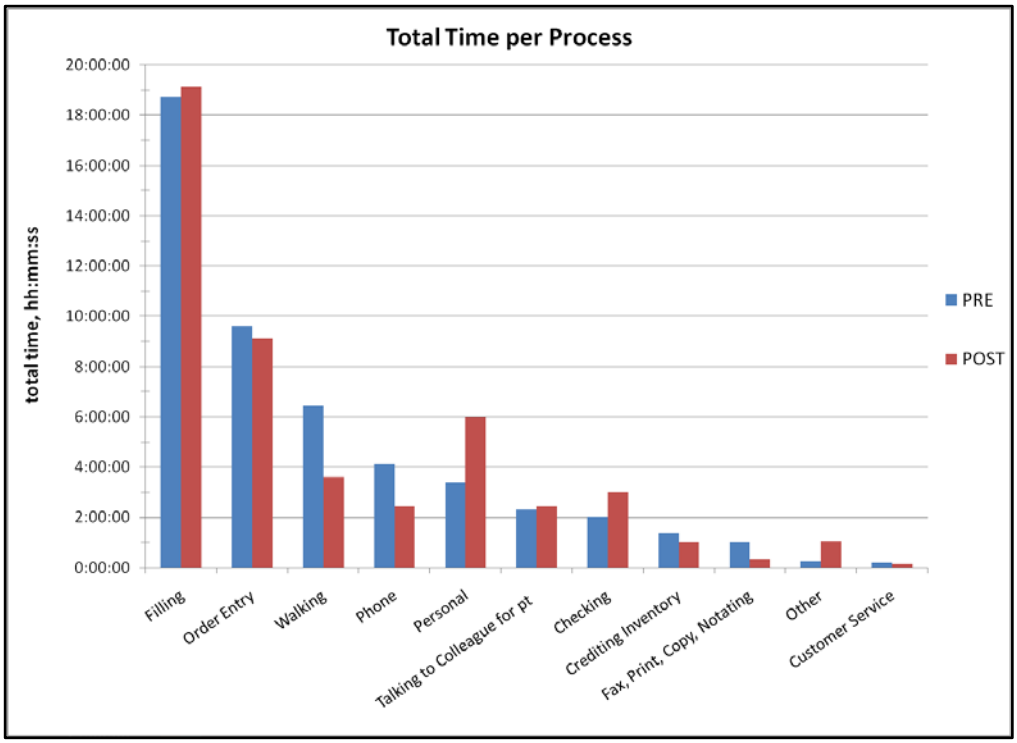



**Figure 10. Total Time Per Process (PRE VS. POST).**

Though not necessarily depicted in the data, the infusion of robotic bar code technology into the pharmacy at MMC had significant impact on staff, processes, and the overall atmosphere of the department. Upon examination of the data collected in 2011 (PRE) compared with data collected in 2013 (POST), multiple workflow process alterations have been noted. The two highest time consuming activities, filling and dedication order entry, were seemingly unaffected by the technology, as well as time spent loading medications into the Pyxis machines.

An expected benefit of automation is the consolidation of inventory in known locations to staff. Pharmacy technicians spent nearly the same amount of time filling medication orders between the PRE and POST time periods. Though one might anticipate a decrease in time spent filling medications due to automation despite a fairly consistent patient census between the time periods, the automation of processes did not significantly impact the time for drug dispensation (i.e. filling).

The results showed a decrease in the amount of time spent crediting inventory; likely due to the automation process now employed to complete this task and/or the distribution of the prescribed quantity and type of drug(s) dispensed to the clinical units. A reduction in phone calls and in handling paper (Fax, Print, Copy, Notating) had been shown during the POST period. This implies fewer calls from clinical units (e.g. nurse) were received questioning the status of ordered medications, as well as less hand-off communications (i.e. paper handling). A reduction in physical walking has also been realized, implying technicians are spending less time traversing to fill medication orders. Such is also demonstrative of the overarching role of the robotic technology – to fill patient prescription orders via automation. The increase in personal time (e.g. meal break) during the POST assessment was seen as a positive outcome from the perspective of employee satisfaction and perhaps increased task completion efficiency, as pharmacists and technicians were seemingly able to more consistently take scheduled breaks during shifts.

Examination of the data also revealed the following:

- A small decrease in time spent for order entry. This was expected because this process was not primarily impacted by technology upgrades or automation. Computerized physician order entry (CPOE), piloted by a small group of Conemaugh physicians (not included in MIDHT scope), was anticipated to increase efficiencies, but failed to be observed during workflow shadowing.

- A small increase in time spent checking medications. This result was surprising because procedurally only 10% of medications dispensed from the robot are checked by a pharmacist (POST) whereas 100% of all medications manually filled by technicians were reviewed in the PRE period.

Efficiency gains were likely not quantitatively realized for this process however. Fewer disruptions would allow staff to complete tasks at hand. During the PRE observations many staff did not break for mealtime, etc. since the backlog of work was always present. While backlog in the POST was still present, staff had more confidence in the processes and cooperation between each other to actually take a break.

In addition to the specific discussions in regards to the pharmacy workflow analyses of the PRE (2011) and POST (2013) periods, it must be realized that in addition to significant daily operational changes, the organizational leadership within the pharmacy also experienced changes during this time period. In as

much, differences not only in daily operations, but also workgroup demeanor, have likely influenced results.

### 1.2.4 Robotic Dispensing to MYMC

Figure 11 displays the number of robotic dispenses per month that were sent via courier to rural MYMC 50 minutes to the south. Despite having no in-house pharmacy, MYMC was fully integrated into the BCMA process with support from the flagship hospital MMC.

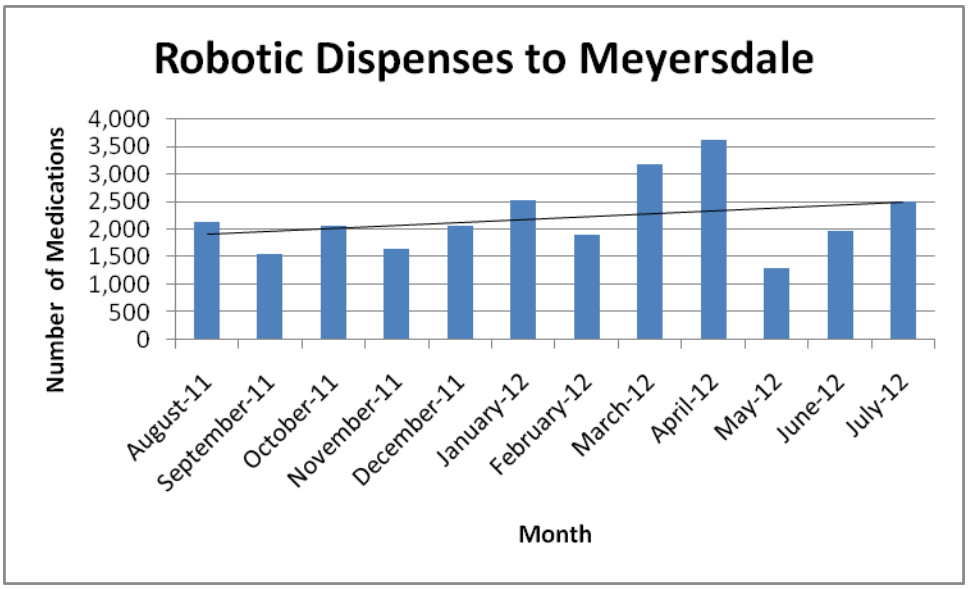



**Figure 11. Robotic Dispensing to MYMC.**

### 1.2.5 Medication Expenditures and Year-Ending Inventory

The raw data consisting of medication expenses (US $) for MMC provided by the organization's Finance Department [(FY 2009 – 2011 (PRE) and FY 2012 – 2013 (POST)] was converted using two different indices: average annual percent change of brand drug prices published by AARP, Inc. and inflation as reported by the US Bureau of Labor Statistics (PRNewswire-USNewswire n.d.). The percent change price index most likely better reflects the true increase in medication expense over time, as the prescription drug expenditure contribution to the CPI-U (inflation) is quite small – typically less than 1%. Therefore, the results for the analysis of medication expenses adjusted using the percent change price index follows. An independent-samples t-test was used to determine if a statistically significant difference existed between the mean medication expense for the pre (n=12) and post (n=8) time periods. The data did not exhibit outliers and was sufficiently normal for each level of time period as assessed by inspection of box plots, Q-Q plots, and the Shapiro-Wilk's test (***p*** > .05). Homogeneity of variances held, as assessed by Levene's test for equality of variances (***p*** = .611). As further evidence of homogeneity of data on time period, a t-test revealed that MMC medication dosage data showed no statistically significant mean difference between time periods (post – pre), *Mdif* = 5,281 +/- 23,350, *p* = .6443. The mean difference, Mdif, of medication expense (post – pre) was found to be a statistically significant

decrease at alpha = .05, *Mdif* = - $713,596.33, *SE* = $87,459.31, 95% CI [$529,851.13, $897,341.52], *t*(18) = 8.159, *p* < .0005, *d* = .19. This result should be viewed with some caution as the AARP source is retail-based although MMC typically dispenses 75-80% brand name medications.

An independent samples t-test was attempted on the change in the ending drug inventory value (from MMC Balance Sheet FY 2009 - 2013) from Pre (n=3) to Post (n=2). Although these sample sizes are insufficient for valid statistical analysis, the mean difference, adjusting using percent change of price, is most probably not statistically meaningful, Mdif = - $52,327.90.

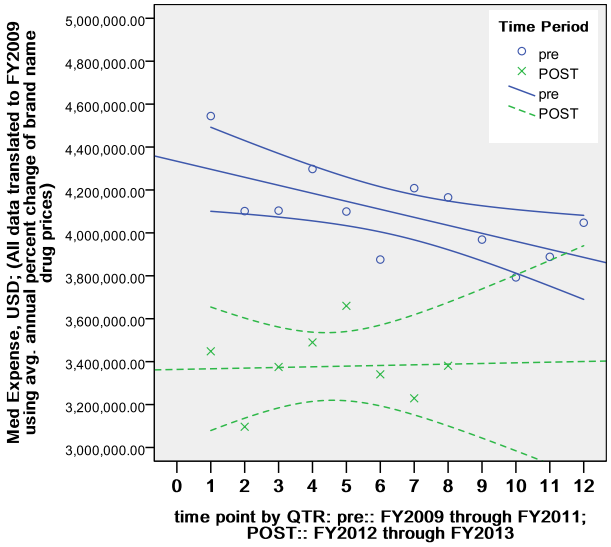



**Figure 12. Linear Regression with 95% CI curves of mean, data adjusted annual percent change of brand name drug prices.**

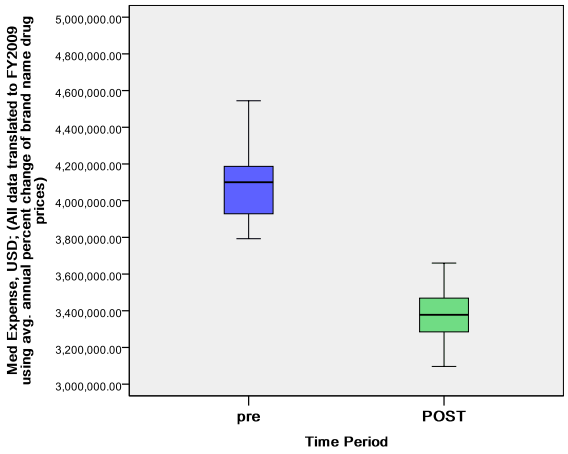



**Figure 13. Box Plot, data adjusted using average using average annual percent change of brand name drug prices.**

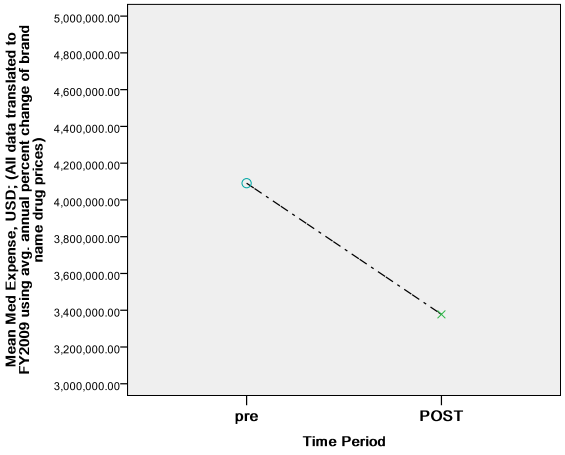



**Figure 14. Means Plot, data adjusted using average annual percent change of brand name drug prices.**

### 1.2.6 Non-returnable Expired Medications – MMC & MYMC

The quantity and cost of expired medications were compared by time period for MMC & MYMC. Data was retrieved electronically from Guaranteed Returns, the hospital's vendor that handles expired medications. An independent t-test revealed no statistically significant difference between time periods for the mean cost or quantity of expired medications. Please refer to
Table 3. The distribution of both cost and quantity by time period was also compared using the Mann-Whitney U test; the distributions were found not to be statistically significantly different. The vendor promised reduction in expired medications was not our experience. MIMC was removed from the scope as the pharmacy robotics implementation did not have a large impact on operations whereas MMC pharmacy directly supports MYMC.

| Time period | | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Quantity | Pre | 19 | 466.26 | 205.542 | 47.155 |
| | Post | 12 | 514.25 | 91.844 | 26.513 |
| Cost, USD | Pre | 19 | $18,726.00 | $12,294.76 | $2,820.61 |
| | Post | 12 | $19,936.50 | $10,391.10 | $2,999.65 |

**Table 3. Non-returnable Expired Medications.**

### 1.2.7 MMC Pharmacy Call Volume (Re-budget Item)

From the time of request to the Telecommunications Department, 16 months of data was available/held in the reporting system. Although data before the Pharmacy system v10.1 upgrade is not displayed, Figure 15 does not support a reduction in incoming phone calls to the MMC Pharmacy during the Post period. Phone calls to the Employee Pharmacy section were removed. Outgoing phone calls to internal departments (e.g. Nursing) are not collected by the reporting system.

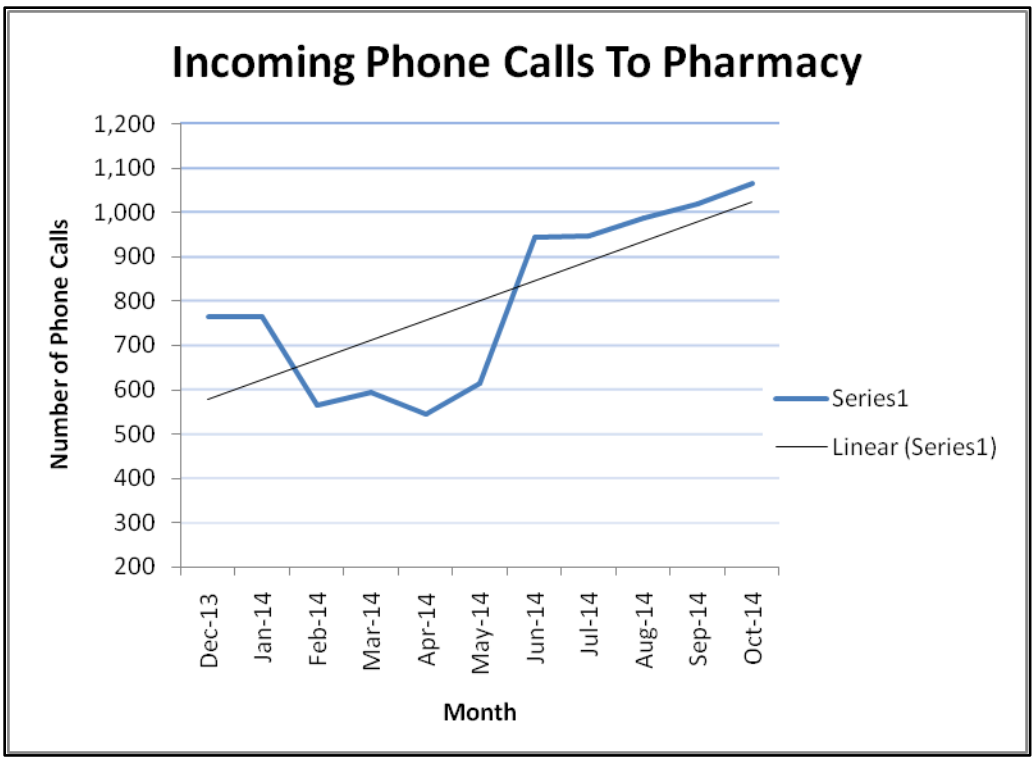



**Figure 15. Incoming Phone Calls to MMC Pharmacy.**

### 1.2.8 Nursing Satisfaction Survey

The Medication Administration System-Nurses' Assessment of Satisfaction (MAS-NAS), developed by Hurley et al (Hurley A 2003) at Brigham and Women's Hospital, was made available through various means to all CHS inpatient nurses in early April 2011 (Appendix E). The overall response from staff had resulted in 262 acceptable surveys, an approximate response rate of 38%. Figure 16 depicted nurse satisfaction with the manual/paper medication administration system (baseline). As depicted, 46% of respondents were satisfied with the current system. This presented a real opportunity to improve nursing satisfaction through the pharmacy robotics and BCMA implementation. The survey was closed for MMC and rural MYMC inpatient nurses but remained open longer for nurses at MIMC. Union negotiations at MIMC were a barrier to receiving additional responses from that facility. Baseline survey collection at MIMC was completed in January 2012.

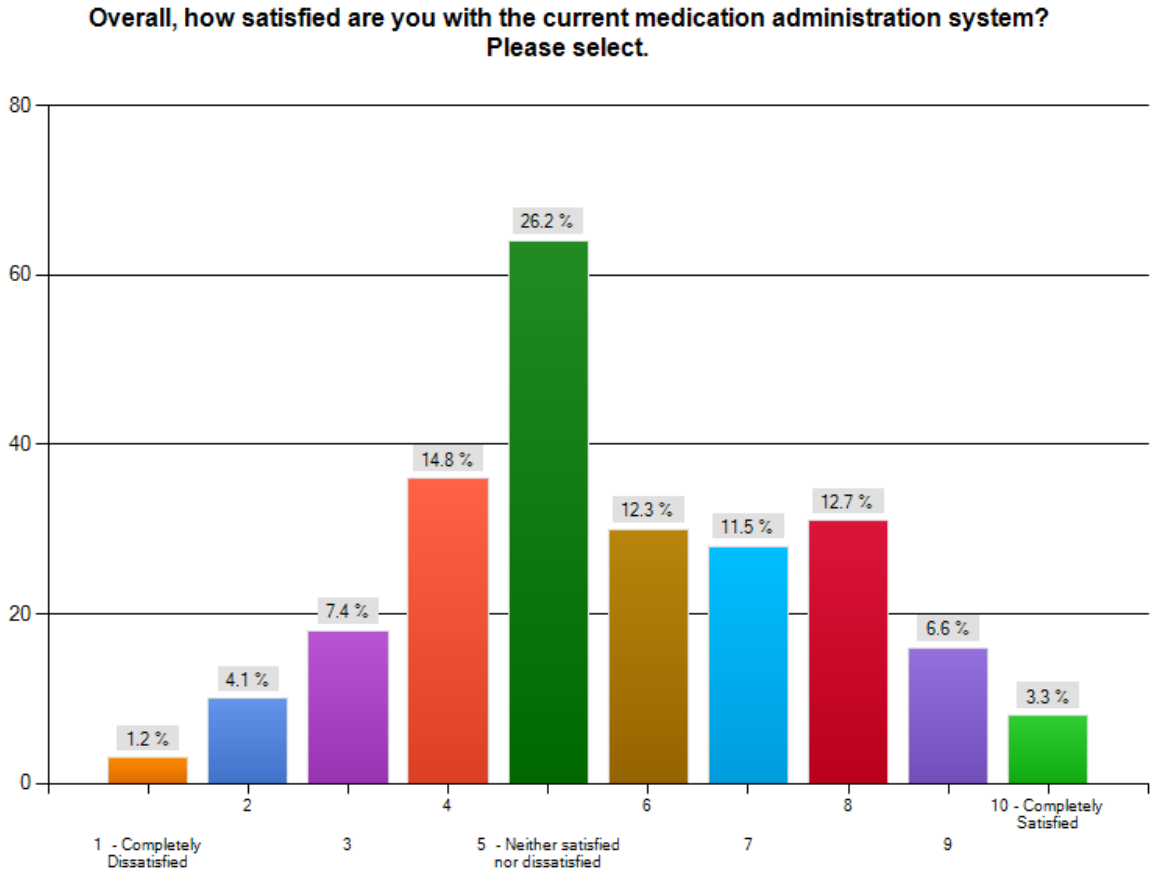



**Figure 16. CHS Nursing Satisfaction with Medication Administration System (Baseline).**

MMC Site

The POST Medication Administration System Survey – Nurses' Assessment Survey was made available to all inpatient nursing and related staff at Memorial Medical Center in early March 2012 (3 months POST). A token incentive was available to staff for properly completed surveys. Communication methods included an article in the employee newsletter, direct communications with nursing managers and placement of the survey link on the Conemaugh intranet page. The objective was to obtain qualitative feedback from BCMA users using a validated survey instrument. Survey distribution (POST) at MYMC was completed in July 2012 (n=28). A second POST distribution (~6 months POST) at MMC began in September 2012 (n=277).

Statistical analyses for all three MMC survey data sets (PRE, POST 1, POST 2) are as follow:

Q30: Overall, how satisfied are you with the current medication administration system?

Q26: I am more satisfied with this new medication administration system than with the previous one.

Taken together, Q30 and Q26, provide an overall picture of the satisfaction of medication administration users. An ANOVA over the three time periods for Q30 yields a significant omnibus (between groups) p-

value, 0.001. The mean satisfaction decreases from Baseline to Post 1 and slightly increases for Post 2. Pairwise analysis yields significant difference between Baseline and Post 1 (p-value, 0.001) and Post 2 (p-value, 0.011) with no significance between post time periods. The mean satisfaction hovers under a value of 5, neither satisfied nor dissatisfied. The change in satisfaction is depicted visually in Figure 17.
Q30: Overall, how satisfied are you with the current medication administration system?

**Q30 Descriptives**

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound | | |
| Baseline | 218 | 5.66 | 1.983 | .134 | 5.40 | 5.93 | 1 | 10 |
| Post 1 | 285 | 4.98 | 2.310 | .137 | 4.71 | 5.24 | 1 | 10 |
| Post 2 | 236 | 5.08 | 2.243 | .146 | 4.80 | 5.37 | 1 | 10 |
| Total | 739 | 5.21 | 2.213 | .081 | 5.05 | 5.37 | 1 | 10 |

NOTE: 1 = Completely Dissatisfied <> 5 = neither <> 10 = Completely Satisfied

Homogeneity of Variance is not preserved between groups, Levene Statistic p-value = .039

**Table 4. Question 30 Descriptives**

**Q30 Multiple Comparisons**

Dependent Variable:Q30

| Multiple Comparison Adjustment | (I) Time Period | (J) Time Period | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound |
| Games-Howell | Baseline | Post 1 | .685* | .192 | .001 | .23 | 1.14 |
| | | Post 2 | .576* | .198 | .011 | .11 | 1.04 |
| | Post 1 | Baseline | -.685* | .192 | .001 | -1.14 | -.23 |
| | | Post 2 | -.109 | .200 | .848 | -.58 | .36 |
| | Post 2 | Baseline | -.576* | .198 | .011 | -1.04 | -.11 |
| | | Post 1 | .109 | .200 | .848 | -.36 | .58 |

*. The mean difference is significant at the 0.05 level.

**Table 5. Question 30 Multiple Comparisons.**

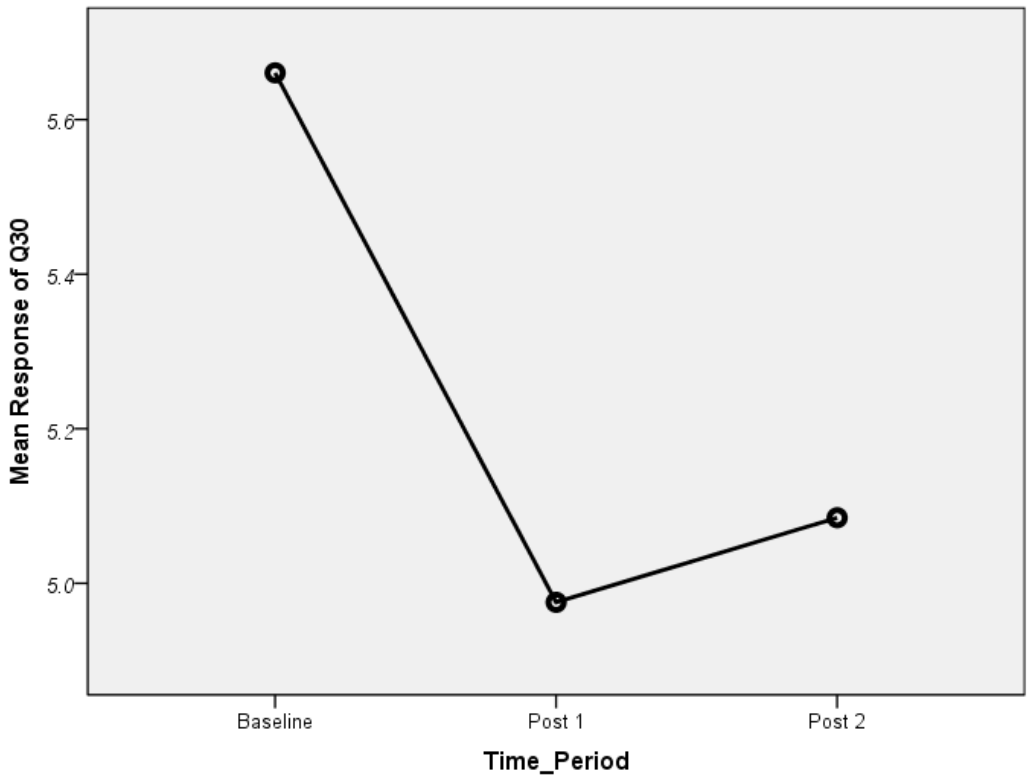



**Figure 17. Question 25: I am more satisfied with this new medication system, BCMA, than with the previous one.**

**Q26 Descriptives**

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound | | | |
| Post 1 | 288 | 3.66 | 1.613 | .095 | 3.47 | 3.85 | 1 | 6 | |
| Post 2 | 236 | 3.63 | 1.682 | .110 | 3.41 | 3.84 | 1 | 6 | |
| **Total** | **524** | **3.65** | 1.643 | .072 | 3.50 | 3.79 | 1 | 6 | |

a. Between-component variance is negative. It was replaced by 0.0 in computing this random effects measure.
b. Homogeneity of Variance preserved between Post 1 and 2

**Table 6. Question 26 Descriptives.**

Since the ANOVA p-value, 0.821, is not statistically significant, Post 1 and Post 2 can be treated collectively for Q26. The mean score of Q26 is consistent with the results of Q30 in that the respondents do not favor the new BCMA system over the original system.

Although the respondents do not favor BCMA over the original manual system, they do consider BCMA to be safer as indicated by the mean value of Q24, 2.63, between moderately and slightly agree.

Q24: This is a safer system for patients.

**Q24 Descriptives**

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound | | | |
| Post 1 | 287 | 2.67 | 1.486 | .088 | 2.50 | 2.85 | 1 | 6 | |
| Post 2 | 237 | 2.59 | 1.512 | .098 | 2.39 | 2.78 | 1 | 6 | |
| **Total** | **524** | **2.63** | 1.497 | .065 | 2.51 | 2.76 | 1 | 6 | |

a. Between-component variance is negative. It was replaced by 0.0 in computing this random effects measure.
b. Homogeneity of Variance preserved between Post 1 and 2

**Table 7. Question 24 Descriptives.**

Since the ANOVA p-value, 0.513, is not statistically significant, Post 1 and Post 2 can be treated collectively for Q24.

Questions 4, 5, 6, 7, 13, 15, and 18 can be interpreted as a response block which provides insight into the perception of the change-in medication reconciliation and safety.

Q04: Because of information available through the current medication administration system I know both the intended actions and side effects of medications I administer.

Q05: I find the drug alert feature (drug/drug or drug/food interaction) of the current medication administration system helpful.

Q06: The current medication administration system makes it easy to check active medication orders before administering medications.

Q07: The current medication administration system provides me with information to know that a medication order has been checked by a pharmacist before I administer the medication.

Q13: The current medication administration system makes it easy to check that I am following the "5 rights" when I administer medications.

Q15: The current medication administration system is effective in reducing and preventing medication errors.

Q18: Information available through the current medication administration system helps me to know what to do should my patient have any bad reactions from a medication.

Omnibus ANOVA p-values showed significance for Q04, Q06, Q07, and Q15. Homogeneity of variance was preserved for all questions except Q07.

Multiple pairwise comparisons by time period yield significant differences between Baseline and at least one Post period. Q04 shows improvement over baseline, while Q05, Q06, and Q15 display a decline.

| Question | omnibus ANOVA (betweeen groups) | MEAN | | |
|---|---|---|---|---|
| | p-value | Baseline | Post 1 | Post 2 |
| *Q04* | 0.001 | 2.93 | 3.18 | 3.52 |
| Q05 | 0.091 | 2.87 | 2.56 | 2.73 |
| *Q06* | 0.036 | 2.85 | 2.77 | 2.50 |
| *Q07* | 0 | 2.91 | 2.43 | 2.40 |
| Q13 | 0.169 | 2.46 | 2.34 | 2.22 |
| *Q15* | 0.029 | 3.35 | 3.17 | 2.97 |
| Q18 | 0.408 | 3.85 | 3.68 | 3.85 |
| Valid N (listwise) >>>>>>>>>>>>>>>>> | | 214 | 275 | 232 |

**Table 8. Omnibus ANOVA for Multiple Questions.**

| Multiple Comparisons | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | 95% Confidence Interval | |
| Question (DV) | Multiple Comparison Adjustment | (I) Time Period | (J) Time Period | Mean Difference (I-J) | Std. Error | Sig. | Lower Bound | Upper Bound |
| Q04 | Sidak | Baseline | Post 1 | -0.252 | 0.153 | 0.268 | -0.62 | 0.11 |
| | | | Post 2 | -.595* | 0.16 | 0.001 | -0.98 | -0.21 |
| | | Post 1 | Baseline | 0.252 | 0.153 | 0.268 | -0.11 | 0.62 |
| | | | Post 2 | -0.343 | 0.152 | 0.07 | -0.71 | 0.02 |
| | | Post 2 | Baseline | .595* | 0.16 | 0.001 | 0.21 | 0.98 |
| | | | Post 1 | 0.343 | 0.152 | 0.07 | -0.02 | 0.71 |
| Q06 | Sidak | Baseline | Post 1 | 0.085 | 0.136 | 0.898 | -0.24 | 0.41 |
| | | | Post 2 | .349* | 0.142 | 0.042 | 0.01 | 0.69 |
| | | Post 1 | Baseline | -0.085 | 0.136 | 0.898 | -0.41 | 0.24 |
| | | | Post 2 | 0.264 | 0.135 | 0.143 | -0.06 | 0.59 |
| | | Post 2 | Baseline | -.349* | 0.142 | 0.042 | -0.69 | -0.01 |
| | | | Post 1 | -0.264 | 0.135 | 0.143 | -0.59 | 0.06 |
| Q07 | Games-Howell | Baseline | Post 1 | .476* | 0.135 | 0.001 | 0.16 | 0.79 |
| | | | Post 2 | .506* | 0.141 | 0.001 | 0.17 | 0.84 |
| | | Post 1 | Baseline | -.476* | 0.135 | 0.001 | -0.79 | -0.16 |
| | | | Post 2 | 0.03 | 0.122 | 0.969 | -0.26 | 0.32 |
| | | Post 2 | Baseline | -.506* | 0.141 | 0.001 | -0.84 | -0.17 |
| | | | Post 1 | -0.03 | 0.122 | 0.969 | -0.32 | 0.26 |
| Q15 | Sidak | Baseline | Post 1 | 0.176 | 0.134 | 0.468 | -0.15 | 0.5 |
| | | | Post 2 | .374* | 0.14 | 0.024 | 0.04 | 0.71 |
| | | Post 1 | Baseline | -0.176 | 0.134 | 0.468 | -0.5 | 0.15 |
| | | | Post 2 | 0.197 | 0.132 | 0.356 | -0.12 | 0.51 |
| | | Post 2 | Baseline | -.374* | 0.14 | 0.024 | -0.71 | -0.04 |
| | | | Post 1 | -0.197 | 0.132 | 0.356 | -0.51 | 0.12 |
| *. The mean difference is significant at the 0.05 level. | | | | | | | | |

**Table 9. Multiple Comparisons for Questions 5, 6, 7 & 15.**

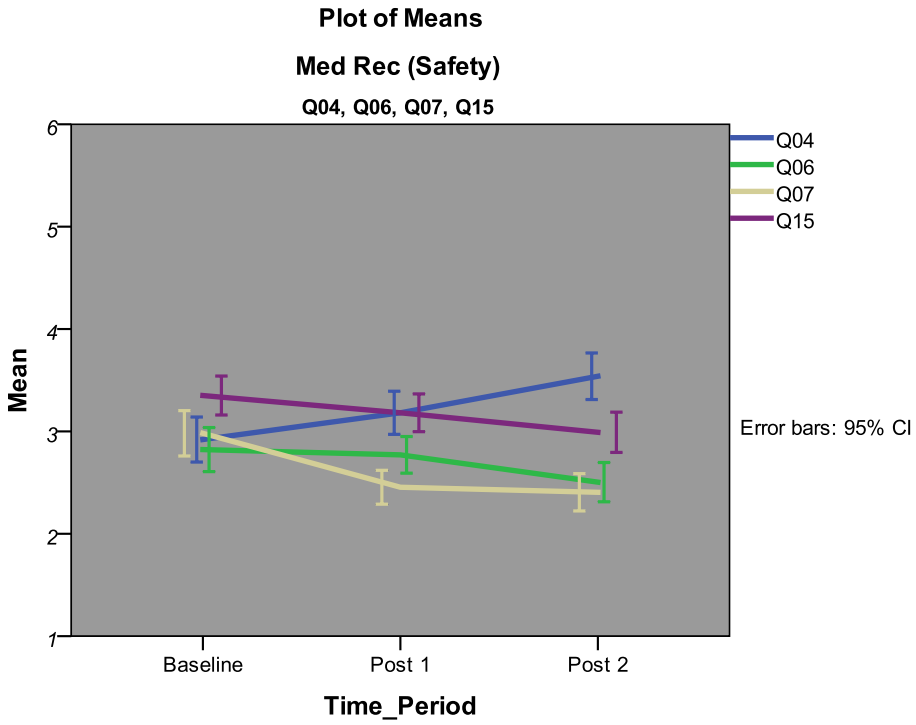



**Figure 18. Medication Safety Questions (Plot of Means).**

As a block, the questions asking solely about the BCMA system show a rather neutral mean response as depicted by Figure 19. This is consistent with the results discussed earlier for overall satisfaction.

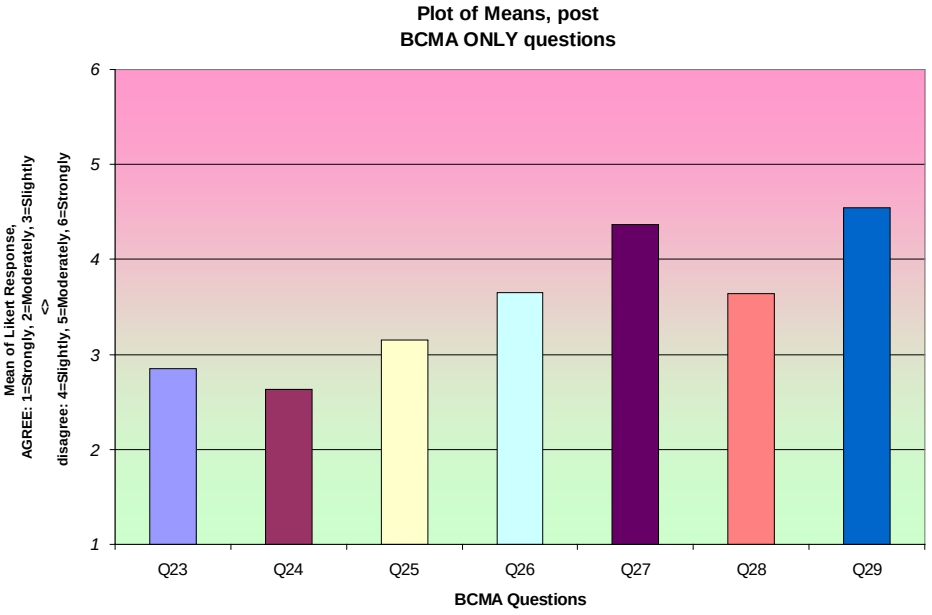



**Figure 19. BCMA Questions (Plot of Means).**

Q23: It is easier to do all the checking steps needed during the medication administration process.

Q24: This is a safer system for patients.

Q25: With the new system, it is easier to access information I need to administer medications.

Q26: I am more satisfied with this new medication administration system than with the previous one.

Q27: I have more time to spend with patients.

Q28: Barcode/eMAR has made the medication administration process more efficient for me.

Q29: Medications are more readily available when I need them for patients.

The pairwise (same person completing survey at multiple time points) analysis is as follows:

A repeated-measures analysis of variance (RM-ANOVA) was completed between Baseline and Post 1 and Baseline and Post 2 periods over the same questions as were analyzed for the one-way ANOVA. The Sidak formula was used to adjust for multiple comparisons. Overall alpha (family-wise) remained at 0.05. These results support the conclusions of non-pairwise analysis. Unfortunately respondent error with creation of the "SUM" ID and a lack of trust by nurses in order to protect their identity prevented a higher sample size.

| Time Periods | Question | Later time - baseline | Mean Difference over TIME | p-value | Correction for non-sphericity |
|---|---|---|---|---|---|
| Baseline and Post 1, N = 35 | Q30 | decrease | -1.143 | 0.008 | |
| | Q04 | | | NS | |
| | Q05 | | | NS | |
| | Q06 | | | NS | |
| | Q07 | decrease | -0.788 | 0.011 | Univariate results, Greenhouse-Geisser |
| | Q13 | | | NS | |
| | Q15 | | | NS | |
| | Q18 | | | NS | |
| | | | | | |
| Baseline and Post 2, N = 26 | Q30 | | | NS | |
| | Q04 | increase | 0.846 | 0.023 | Univariate results, Greenhouse-Geisser |
| | Q05 | | | NS | |
| | Q06 | | | NS | |
| | Q07 | decrease | -0.808 | 0.034 | Univariate results, Greenhouse-Geisser |
| | Q13 | | | NS | |
| | Q15 | increase | 0.192 | 0.019 | Univariate results, Greenhouse-Geisser |
| | Q18 | | | NS | |

NS = No Significance

**Table 10. Repeated Measures ANOVA.**

Q30: Overall, how satisfied are you with the current medication administration system?

Answer Choices: 1 = Completely Dissatisfied <> 5 = neither <> 10 = Completely Satisfied

- means, Baseline = 5.63; Post 1 = 4.49
- The results above indicate a statistically significant decrease in satisfaction of BCMA from baseline to post 1.

*A 6-point Likert scale was used for the remaining questions under analysis:*

| | | |
|---|---|---|
| 1 Strongly Agree | 3 Slightly Agree | 5 Moderately Disagree |
| 2 Moderately Agree | 4 Slightly Disagree | 6 Strongly Disagree |
| 0 NA Not Applicable | | |

Please refer to the tables below for quantification of the mean score for the following questions by time period.

Q04: Because of information available through the current medication administration system I know both the intended actions and side effects of medications I administer.

- The results above indicate a statistically significant improvement of perception of knowledge after implementation of BCMA as compared to baseline.

Q07: The current medication administration system provides me with information to know that a medication order has been checked by a pharmacist before I administer the medication.

- The results above indicate a statistically significant decrease in the perception of the knowledge that the medication order has been checked by a pharmacist before administration by the nurse after implementation of BCMA as compared to baseline.

Q15: The current medication administration system is effective in reducing and preventing medication errors.

- The results above indicate a statistically significant improvement of perception of the effectiveness of BCMA to reduce and prevent medication errors as compared to baseline.

**Descriptive Statistics: Baseline(_1) – Post 1 (_2)**

| | Mean | Std. Deviation | N |
|---|---|---|---|
| Q07_1 | 2.94 | 1.694 | 33 |
| Q07_2 | 2.15 | .906 | 33 |

**Descriptive Statistics: Baseline(_1) – Post 2 (_3)**

| | Mean | Std. Deviation | N |
|---|---|---|---|
| Q04_1 | 2.73 | 1.589 | 26 |
| Q04_3 | 3.58 | 1.901 | 26 |
| Q07_1 | 3.31 | 1.436 | 26 |
| Q07_3 | 2.50 | 1.273 | 26 |
| Q15_1 | 3.65 | 1.231 | 26 |
| Q15_3 | 3.00 | 1.497 | 26 |

**Table 11. Descriptive Statistics.**

MYMC Site

The second POST survey was distributed to nursing staff at MYMC in early January 2013. A total of 17 surveys were completed within four weeks, with two of those surveys not 100% complete so the sample size varies from 15-17 depending on question.

Below are the final results for all three survey distributions at MYMC:

Responses to Questions 4-19 and 23-29 were coded 0 – 6, inclusive, with the following meaning:

| 0 = N/A (not applicable) | |
|---|---|
| 1 = Strongly Agree | 4 = Slightly Disagree |
| 2 = Moderately Agree | 5 = Moderately Disagree |
| 3 = Slightly Agree | 6 = Strongly Disagree |

Q30 was coded from 1 – 10 with a between response interval = 1, where:

*1 = completely dissatisfied, 5 = neither satisfied/dissatisfied, 10 = completely satisfied*

These response scales are ordinal and approximately interval. In order to take advantage of the more powerful parametric tests, the scale has been assumed continuous. As this is an assumption for analysis only, non-parametric tests were also applied to check consistency of the analysis.

The following analyses are between-group, pre vs. post 1 vs. post 2 study time periods, with a family-wise alpha criteria = 0.05. When homogeneity of variances held, the Bonferroni correction was applied for pairwise comparisons; when not, Games-Howell was used.

Survey Section 3: Q04-08

Homogeneity of variances (over study time periods) held for all questions.

Only Q04 showed a statistically significant omnibus ANOVA, p-value = 0.024. The pairwise results follow and show significant results between the pre and post 1 periods, p-value = 0.037.

**Multiple Comparisons**

Bonferroni

| Dependent Variable | (I) Study Time Period | (J) Study Time Period | Mean Difference (I-J) | Std. Error | ***Sig.*** | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound |
| S3_Q04: Because of information available through the current medication administration system I know both the intended actions and side effects of medications I administer. | PRE (before BCMA) *N,PRE = 19* | Post 1 (BCMA stabilization) | -1.498* | .579 | ***.037*** | -2.93 | -.07 |
| | | Post 2 (BCMA) | -1.480 | .641 | .073 | -3.06 | .10 |
| | Post 1 (BCMA stabilization) *N,Post 1 = 26* | PRE (before BCMA) | 1.498* | .579 | .037 | .07 | 2.93 |
| | | Post 2 (BCMA) | .018 | .599 | 1.000 | -1.46 | 1.49 |
| | Post 2 (BCMA) *N,Post 2 = 17* | PRE (before BCMA) | 1.480 | .641 | .073 | -.10 | 3.06 |
| | | Post 1 (BCMA stabilization) | -.018 | .599 | 1.000 | -1.49 | 1.46 |

*. The mean difference is significant at the 0.05 level.

**Table 12. Question 4 Statistical Results.**

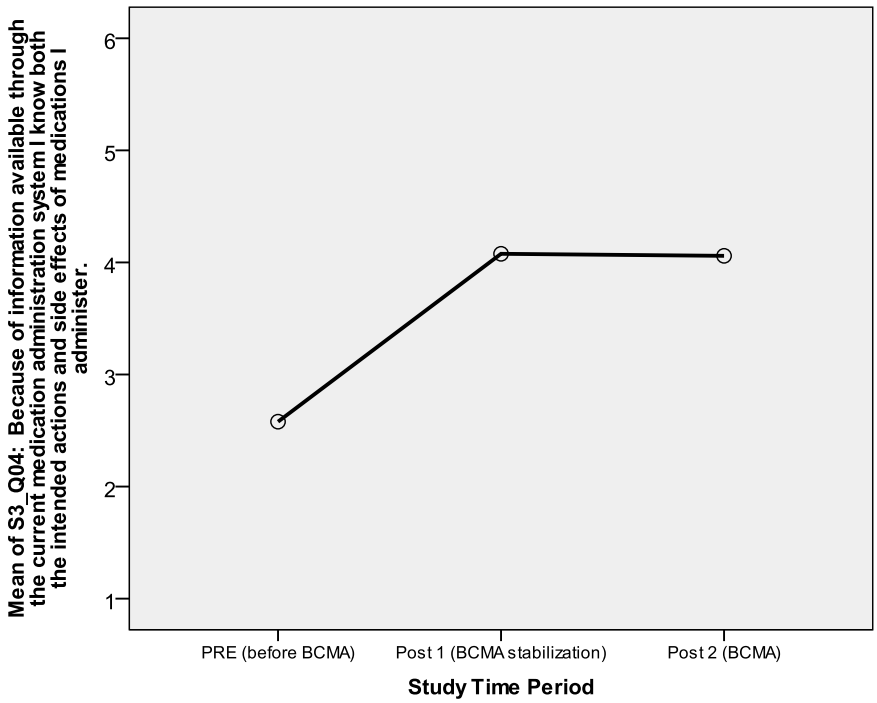



**Figure 20. Graphical Representation of Question 4 Results.**

Survey Section 4: Q09-19

Homogeneity of variances (over study time periods) held for all questions except Q12 and Q13.

The following questions showed a statistically significant omnibus ANOVA:

| Question | p-value | N,PRE | N,Post 1 | N,Post 2 |
|---|---|---|---|---|
| Q10 | 0.028 | 19 | 26 | 17 |
| Q12 | <0.0005 | 19 | 26 | 16 |
| Q13 | 0.020 | 18 | 26 | 16 |
| Q16 | 0.025 | 18 | 25 | 17 |

The pairwise results follow and show significant results between:

| Question | p-value | pairwise study time periods |
|---|---|---|
| Q10 | 0.033 | PRE and Post 1 |
| Q12 | <0.0005 | PRE and Post 1 |
| | 0.003 | PRE and Post 2 |
| Q13 | 0.008 | PRE and Post 1 |
| | 0.048 | PRE and Post 2 |
| Q16 | 0.017 | PRE and Post 1 |

**Multiple Comparisons**

| Dependent Variable | | (I) Study Time Period | (J) Study Time Period | Mean Difference (I-J) | Std. Error | *Sig.* | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower Bound | Upper Bound |
| S4_Q10: The drug information available through the current medication administration system is easy to get when I need that information. | Bonferroni | PRE (before BCMA) | Post 1 (BCMA stabilization | -1.344* | .512 | ***.033*** | -2.60 | -.08 |
| | | | Post 2 (BCMA) | -1.186 | .566 | .121 | -2.58 | .21 |
| | | Post 1 (BCMA stabilization) | PRE (before BCMA) | 1.344* | .512 | .033 | .08 | 2.60 |
| | | | Post 2 (BCMA) | .158 | .529 | 1.000 | -1.14 | 1.46 |
| | | Post 2 (BCMA) | PRE (before BCMA) | 1.186 | .566 | .121 | -.21 | 2.58 |
| | | | Post 1 (BCMA stabilization) | -.158 | .529 | 1.000 | -1.46 | 1.14 |
| S4_Q12: The current medication administration system helps me to be efficient at medication administration. | Games-Howell | PRE (before BCMA) | Post 1 (BCMA stabilization) | -2.279* | .457 | ***.000*** | -3.39 | -1.17 |
| | | | Post 2 (BCMA) | -2.020* | .544 | ***.003*** | -3.38 | -.66 |
| | | Post 1 (BCMA stabilization) | PRE (before BCMA) | 2.279* | .457 | .000 | 1.17 | 3.39 |
| | | | Post 2 (BCMA) | .260 | .614 | .906 | -1.25 | 1.77 |
| | | Post 2 (BCMA) | PRE (before BCMA) | 2.020* | .544 | .003 | .66 | 3.38 |
| | | | Post 1 (BCMA stabilization) | -.260 | .614 | .906 | -1.77 | 1.25 |
| S4_Q13: The current medication administration system makes it easy to check that I am following the "5 rights" when I administer medications. | Games-Howell | PRE (before BCMA) | Post 1 (BCMA stabilization) | -1.453* | .456 | ***.008*** | -2.56 | -.34 |
| | | | Post 2 (BCMA) | -1.472* | .579 | ***.048*** | -2.93 | -.01 |
| | | Post 1 (BCMA stabilization) | PRE (before BCMA) | 1.453* | .456 | .008 | .34 | 2.56 |
| | | | Post 2 (BCMA) | -.019 | .656 | 1.000 | -1.64 | 1.60 |
| | | Post 2 (BCMA) | PRE (before BCMA) | 1.472* | .579 | .048 | .01 | 2.93 |
| | | | Post 1 (BCMA stabilization) | .019 | .656 | 1.000 | -1.60 | 1.64 |
| S4_Q16: The current medication administration system is user-friendly to the nurses who administer medications. | Games-Howell | PRE (before BCMA) | Post 1 (BCMA stabilization) | -1.456* | .504 | ***.017*** | -2.68 | -.23 |
| | | | Post 2 (BCMA) | -1.173 | .552 | .101 | -2.53 | .19 |
| | | Post 1 (BCMA stabilization) | PRE (before BCMA) | 1.456* | .504 | .017 | .23 | 2.68 |
| | | | Post 2 (BCMA) | .282 | .575 | .876 | -1.12 | 1.69 |
| | | Post 2 (BCMA) | PRE (before BCMA) | 1.173 | .552 | .101 | -.19 | 2.53 |
| | | | Post 1 (BCMA stabilization) | -.282 | .575 | .876 | -1.69 | 1.12 |

**Table 13. Questions 10, 12, 13 & 16 Statistical Results.**

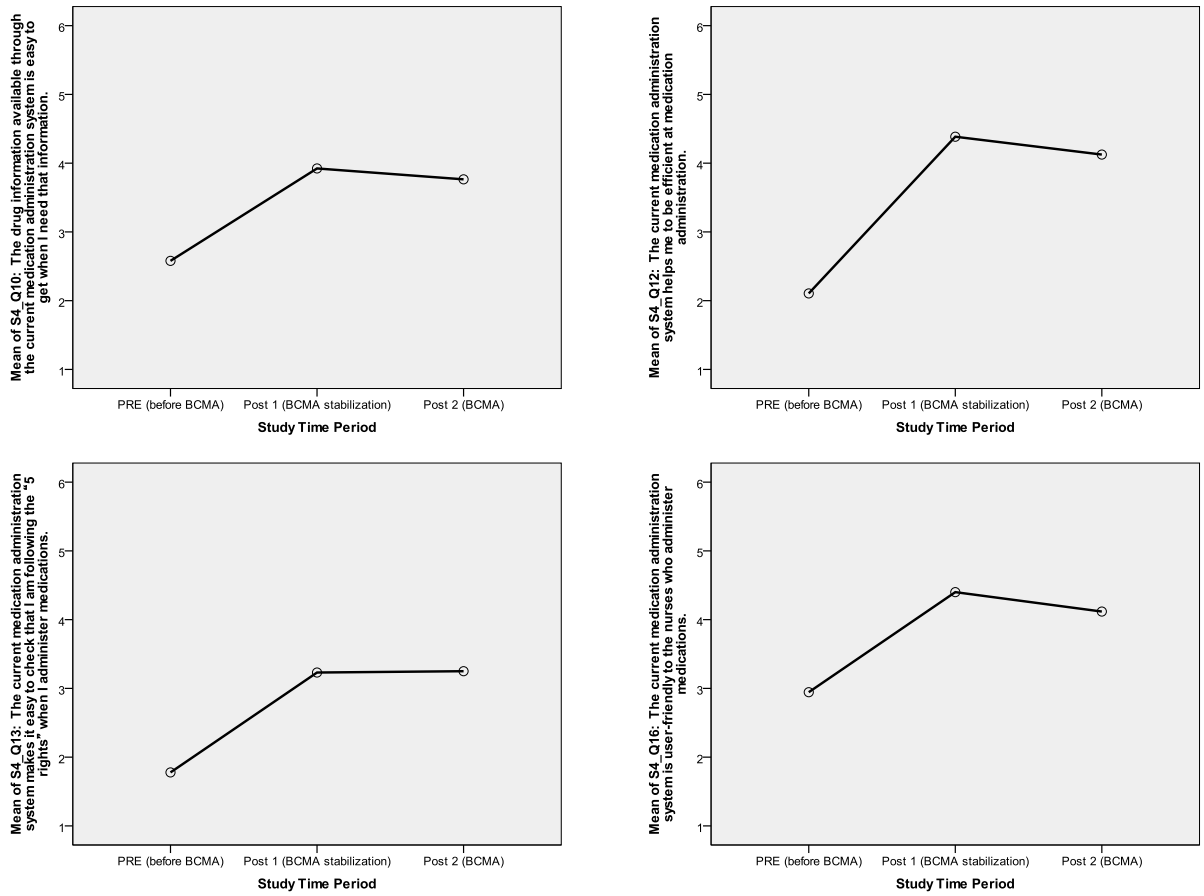



**Figure 21. Graphical Representation of Question 10, 12, 13 & 16 Results.**

Survey Section 7: Q23-29

Homogeneity of variances (over study time periods) held for all questions.

No questions showed a statistically significant omnibus ANOVA.

Question 30: Overall, how satisfied are you with the current medication administration system?

Homogeneity of variances (over study time periods) held for this question. This question showed a statistically significant omnibus ANOVA, p-value = 0.023 and indicates a trend of increasing dissatisfaction from pre to post time periods. Figure 28 shows the dissatisfaction at MYMC (rural facility) was slightly worse than the flagship hospital, MMC, with a greater disparity in satisfaction at MYMC. Please note the sample sizes were drastically different.

The pairwise results follow:

**Multiple Comparisons**

| Dependent Variable | | (I) Study Time Period | (J) Study Time Period | Mean Difference (I-J) | Std. Error | *Sig.* | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower Bound | Upper Bound |
| S_Q30: Overall, how satisfied are you with the current medication administration system? | Bonferroni | PRE (before BCMA) *N,PRE = 17* | Post 1 (BCMA stabilization) | 1.762 | .727 | .056 | -.03 | 3.56 |
| | | | Post 2 (BCMA) | 2.082* | .819 | ***.042*** | .06 | 4.11 |
| | | Post 1 (BCMA stabilization) *N,Post 1 = 25* | PRE (before BCMA) | -1.762 | .727 | .056 | -3.56 | .03 |
| | | | Post 2 (BCMA) | .320 | .755 | 1.000 | -1.55 | 2.19 |
| | | Post 2 (BCMA) *N,Post 2 = 15* | PRE (before BCMA) | -2.082* | .819 | .042 | -4.11 | -.06 |
| | | | Post 1 (BCMA stabilization) | -.320 | .755 | 1.000 | -2.19 | 1.55 |

*. The mean difference is significant at the 0.05 level.

**Table 14. Question 30 Statistical Results.**

Despite the overall dissatisfaction of the BCMA system, a majority of nurses (71%) agreed in Figure 22 positively that the system was effective in reducing and preventing medication errors. These qualitative results will be considered in regards to the quantitative analysis of error counts/rates.

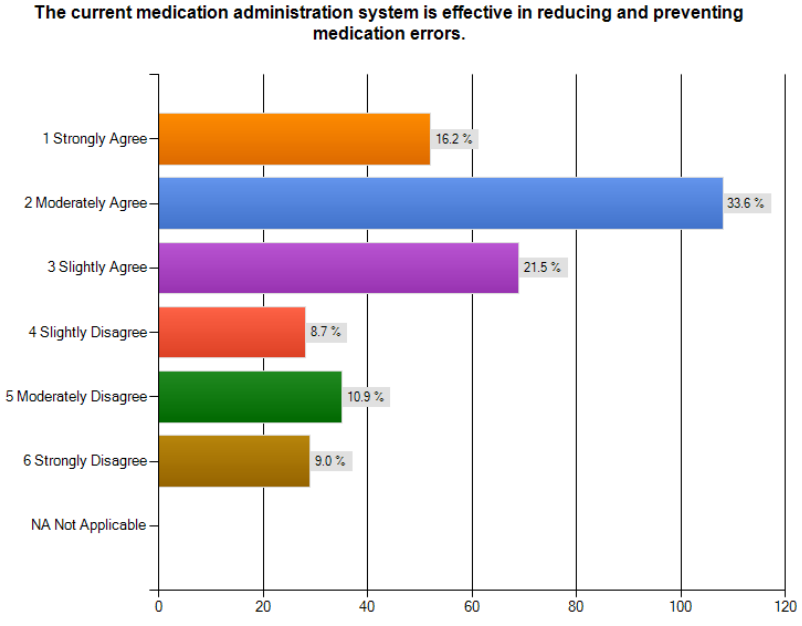



**Figure 22. Nurse Opinion on BCMA Reducing and Preventing Medication Errors, Post 2.**

The survey asked the respondents to input a unique code ("SUM") so that related-samples analysis could be performed over the three time periods, baseline, Post 1, and Post 2. Unfortunately, too few respondents followed the instructions or were employed during all time points. Only six responses were common between baseline and Post 1, seven between baseline and Post 2, and two over all three time periods. This sample size does not meet the generally accepted threshold of ten for analysis to be undertaken.

In conclusion, nursing staff at MYMC is less satisfied with the new BCMA system than the previous manual medication administration system. The second post survey results indicate that satisfaction continued to decline, which is surprising because most users and system effectiveness should be past the learning curve phase at this point. On the other hand, these results are not surprising because users are likely a close-knit group located in a small, rural facility and may be resistant to technological advances. As demonstrated by the comments in Table 7, various issues are present and contributing to their dissatisfaction.

Comments added in response to open-ended survey questions during the Post time periods have been summarized in Table 15 below.

| Issue | Count |
|---|---|
| System not user friendly | 11 |
| Medication profile errors | 6 |
| Barcodes not scanning | 4 |
| Dangerous system | 4 |
| Communication problems between pharmacy and nursing | 3 |
| Medications not easy to find | 2 |
| Easier way to check med orders | 2 |
| Medication info not contained within application | 1 |
| Takes too long to pass medications | 1 |
| Timeliness of drugs dispensed | 1 |

**Table 15. Summary of Comments Received.**

## MIMC Site

The same validated BCMA survey was distributed to nursing staff at MIMC on May 27, 2014 (3 months post- live deployment). The POST survey was closed on June 13, 2014.

MIMC is a 30-bed community hospital serving rural northern Cambria County and surrounding areas, located approximately 45 minutes from Johnstown. A total of 16 nurses gave responses to the survey PRE (2012) and 30 staff nurses and administrators responded to the survey POST BCMA implementation (3 months). All respondents to the POST survey questions worked on the unit before Admin-RX was deployed. Responses below are reported descriptively because questions were not applicable in the PRE survey. The majority of those surveyed responded favorably:

- 75% agreed it is easier to perform all the checking steps needed during the medication administration process;
- more than 90% of respondents agreed this is a safer system for patients;
- Approximately 80% of respondents believed it is easier to access information with the new

system, which implies a positive impact on staff efficiency and patient safety.

- Approximately 80% of respondents believed it takes more time to administer medications with the new system.
- Over 50% of staff believed BCMA has made the medication administration process more efficient for them.

The last results are somewhat contradicted by the previous question if improved efficiency results in spending more time with the patient. The impact of pharmacy automation was minimal at this location as an in-house pharmacy is present. Again, there is disagreement amongst staff regarding the availability of medications. Most respondents probably interpreted this question to be about ease of finding medications, not availability of product.

As Figure 23 displays, satisfaction is spread nearly uniformly across all answer choices. These results are similar to the other two hospitals, MMC and MYMC.

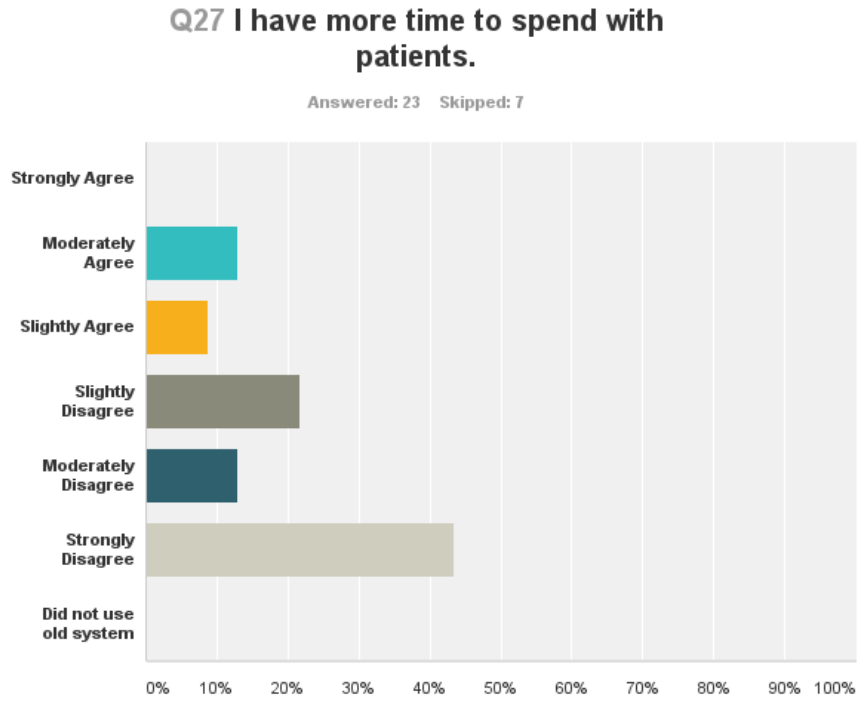



**Figure 23. More Time to Spend With Patients.**

The same survey was distributed at 6 months post implementation in September 2014 to the nursing staff (Post 2) and 20 surveys were completed by the nursing staff. Not all surveys were completed in full, therefore the sample size per question varied.

Demographically, no statistically significant difference was found for the mean, median, or distribution of the following variables (see Table 16). Normality was violated for most of the variables over most time periods, but homogeneity of variance held for all but 'Year at CHS'. An ANOVA was used to test the mean (interpreted with some caution due to normality violation), the Median Test for the median, and the Kruskal-Wallis Test was applied to test the distribution.

| | | Age, years | Years as a Nurse | Years at CHS | Hours worked/wk |
|---|---|---|---|---|---|
| **Pre** | N | **13** | **15** | **14** | **15** |
| | *Mean* | ***50.08*** | ***25.47*** | ***13.29*** | ***39.20*** |
| **Post 1** | N | **28** | **28** | **29** | **28** |
| | *Mean* | ***46.11*** | ***21.27*** | ***8.69*** | ***39.50*** |
| **Post 2** | N | **16** | **19** | **20** | **20** |
| | *Mean* | ***46.13*** | ***20.50*** | ***7.40*** | ***43.80*** |

**Table 16. Demographics of Survey Respondents.**

Due to violations of both normality and homogeneity of variance, non-parametric analyses have been applied in conjunction with a non-pairwise ANOVA in order to provide results with the most depth possible. Since an insufficient number of surveys were able to be matched by "SUM" ID, the pairwise (same person completing survey at different time points) analysis was not possible. Unfortunately respondent error with creation of the "SUM" ID and a lack of trust by nurses in order to protect their identity prevented a sufficient sample size to execute a pairwise analysis. The Sidak formula was used to adjust for multiple tests. Overall alpha (family-wise) remained at 0.05.

Three survey questions showed a statistically significant change (pre vs. post) in Table 17.

A six-point Likert scale was used for these questions.

1 Strongly Agree 3 Slightly Agree 5 Moderately Disagree

2 Moderately Agree 4 Slightly Disagree 6 Strongly Disagree

0 NA Not Applicable

| Survey Question | N | Means | ANOVA, p-values | Kruskal-Wallis Test on the distribution of answers | MEDIANS | Median Test, p-values |
|---|---|---|---|---|---|---|
| The current medication administration system provides me with information to know that a medication order has been checked by a pharmacist before I administer the medication. | Pre = 16<br>Post 1 = 30<br>Post 2 = 20 | Pre = 4<br>Post 1 = 2<br>Post 2 = 2 | < .0005<br>(0,1): .001<br>(0,2): .002 | .004<br>(0,1): .004<br>(0,2): .017 | *Pre = 4*<br>*Post 1 = 2*<br>*Post 2 = 2* | .025<br>(0,1): .026 |
| The current medication administration system promotes 2-way communication between clinicians (MD, Pharmacist, RN) about medication orders. | Pre = 16<br>Post 1 = 30<br>Post 2 = 20 | Pre = 4<br>Post 1 = 3<br>Post 2 = 3 | NS | NS | *Pre = 4*<br>*Post 1 = 3*<br>*Post 2 = 3* | .016<br>(0,1): .028 |
| The turnaround time for receiving medications needed "stat" or for patients newly admitted to the unit is adequate. | Pre = 15<br>Post 1 = 30<br>Post 2 = 20 | Pre = 5<br>Post 1 = 3<br>Post 2 = 3 | .002<br>(0,1): .001<br>(0,2): .032 | .003<br>(0,1): .002 | *Pre = 5*<br>*Post 1 = 2*<br>*Post 2 = 3* | .001<br>(0,1): <.0005<br>(0,2): .017 |
| The current medication administration system is effective in reducing and preventing medication errors. | Pre = 16<br>Post 1 = 30<br>Post 2 = 20 | Pre = 4<br>Post 1 = 2<br>Post 2 = 2 | .001<br>(0,1): .001<br>(0,2): .022 | .008<br>(0,1): .006 | *Pre = 3*<br>*Post 1 = 2*<br>*Post 2 = 2* | NS |

**Table 17. p-values for Stated Questions.**

NOTES:

A. (0,1) and (0,2) refer to the pairwise comparison between Pre and Post 1 or Post 2
B. Any p-value > .013 and < .05 would likely be statistically significant given additional sample size; however, when the more stringent critical p-value is applied adjusting for multiple tests, statistical significance was not strictly achieved.

All questions show approximately a 33% improvement in the post time periods when compared to the pre, shifting from the 'disagree' to the 'agree' portion of the answer scale. Graphical comparison of the distribution of answers by time period follows in Figure 24 and Figure 25:

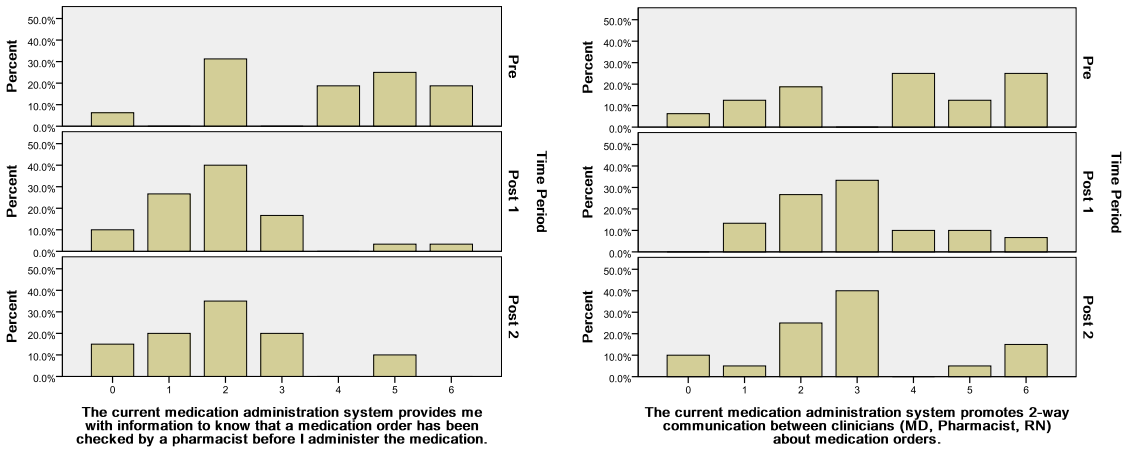



**Figure 24. Pre, Post 1 and Post 2 Comparisons.**

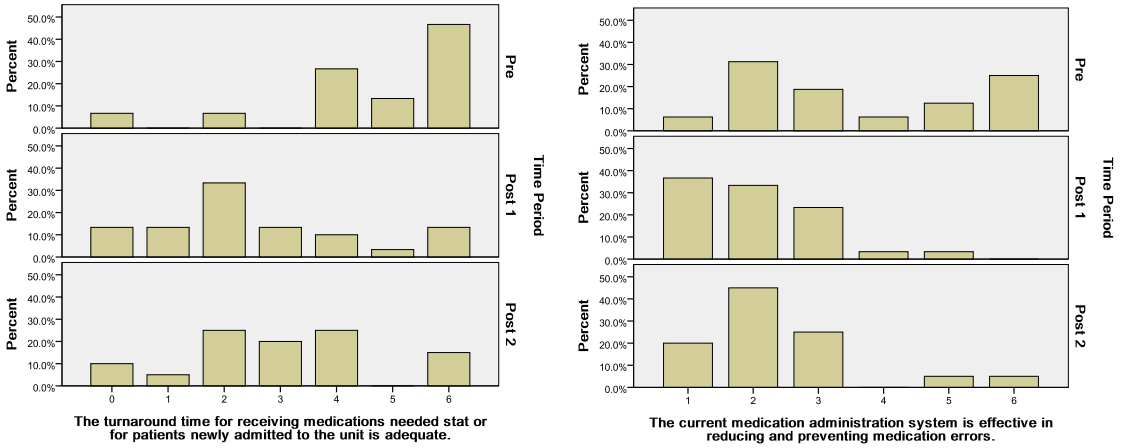



**Figure 25. Pre, Post 1 and Post 2 Comparisons.**

The validated BCMA survey by Hurley et al was completed by nursing staff at all three Conemaugh hospitals (MMC, MIMC and MYMC) at three time points (Baseline, Post 1 and Post 2) requisite to their implementation dates. Table 18 displays the sample size by location and time period (varies by question). All locations show a trend of decreasing satisfaction over time. The trends of MMC and MIMC are more similar to each other than to that of MYMC. MMC and MIMC began slightly satisfied and finished close to a neutral valuation; whereas MYMC began slightly satisfied and finished slightly dissatisfied. This finding is surprising as MMC and MYMC are tightly coupled from an operations standpoint whereas MIMC has an in-house pharmacy and relies less on support from MMC.

| Sample Sizes (max possible) | | time period | | | |
|---|---|---|---|---|---|
| | | baseline | Post 1 | POST 2 | Total |
| Hospital | MMC | **227** | **288** | **262** | **777** |
| | MYMC | **19** | **26** | **17** | **62** |
| | MIMC | **16** | **30** | **20** | **66** |
| Total | | **262** | **344** | **274** | **905** |

**Table 18. Max Sample Size by Location and Time Period.**

Questions 23-29 with the following Likert response scale and corresponding numerical quantification was analyzed using a two-way ANOVA. No interaction effect was found between the two factors, location and time period. The time period main effect was not significant. The location main effect was statistically significant for all but Q25; see Table 19 for details; as such, the differences in each question between levels of location (MMC, MYMC, MIMC) collapsed across time period (post 1, post 2) was statistically significant at an alpha level of .05, see Table 19– Contrast Results.

Q23. It is easier to do all the checking steps needed during the medication administration process.

Q24. This is a safer system for patients.

Q25. With the new system, it is easier to access information I need to administer medications.

Q26. I am more satisfied with this new medication administration system than with the previous one.

Q27. I have more time to spend with patients.

Q28. Barcode/eMAR has made the medication administration process more efficient for me.

Q29. Medications are more readily available when I need them for patients.

| ***Strongly Agree*** | ***Moderately Agree*** | ***Slightly Agree*** | **Slightly Disagree** | **Moderately Disagree** | **Strongly Disagree** |
|---|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** | **6** |

With the exception of Q26, disagreement increased slightly from post 1 to post 2. Also, by time period, MYMC produced a score greater than MMC or MIMC, with the exception of Q25, post 2. Given, with the exception of MYMC, that the scores for MMC and MIMC were in the agree or just slightly disagree

portion of the scale above implies that the BCMA had an overall slightly positive influence on medication administration.

| | Question | | LOCATION F | LOCATION df | LOCATION p-value | TIME PERIOD F | TIME PERIOD df | TIME PERIOD p-value |
|---|---|---|---|---|---|---|---|---|
| Tests of Between-Subjects Effects | 23 | overall by factor, location or time period | 6.573 | 2 | 0.002 | | | NSS |
| | 24 | | 9.376 | 2 | <.0005 | | | NSS |
| | 25 | | | | NSS | | | NSS |
| | 26 | | 6.265 | 2 | 0.002 | | | NSS |
| | 27 | | 5.184 | 2 | 0.006 | | | NSS |
| | 28 | | 5.155 | 2 | 0.006 | | | NSS |
| | 29 | | 3.498 | 2 | 0.031 | | | NSS |
| | | *Pairs* | | | | | | |
| Contrast Results | 23 | MYMC vs MMC | | | < .0005 | | | |
| | 24 | MYMC vs MMC | | | < .0005 | | | |
| | | MYMC vs Miners | | | < .0005 | | | |
| | 25 | | | | NSS | | | |
| | 26 | MYMC vs MMC | | | 0.001 | | | |
| | | MYMC vs Miners | | | 0.003 | | | |
| | 27 | MYMC vs MMC | | | 0.004 | | | |
| | 28 | MYMC vs MMC | | | 0.003 | | | |
| | 29 | Miners vs MMC | | | 0.016 | | | |
| | | MYMC vs Miners | | | 0.016 | | | |

NSS: not statistically significant

where: MMC = Memorial and MYMC = Meyersdale

**Table 19. Statistical Results for Stated Questions.**

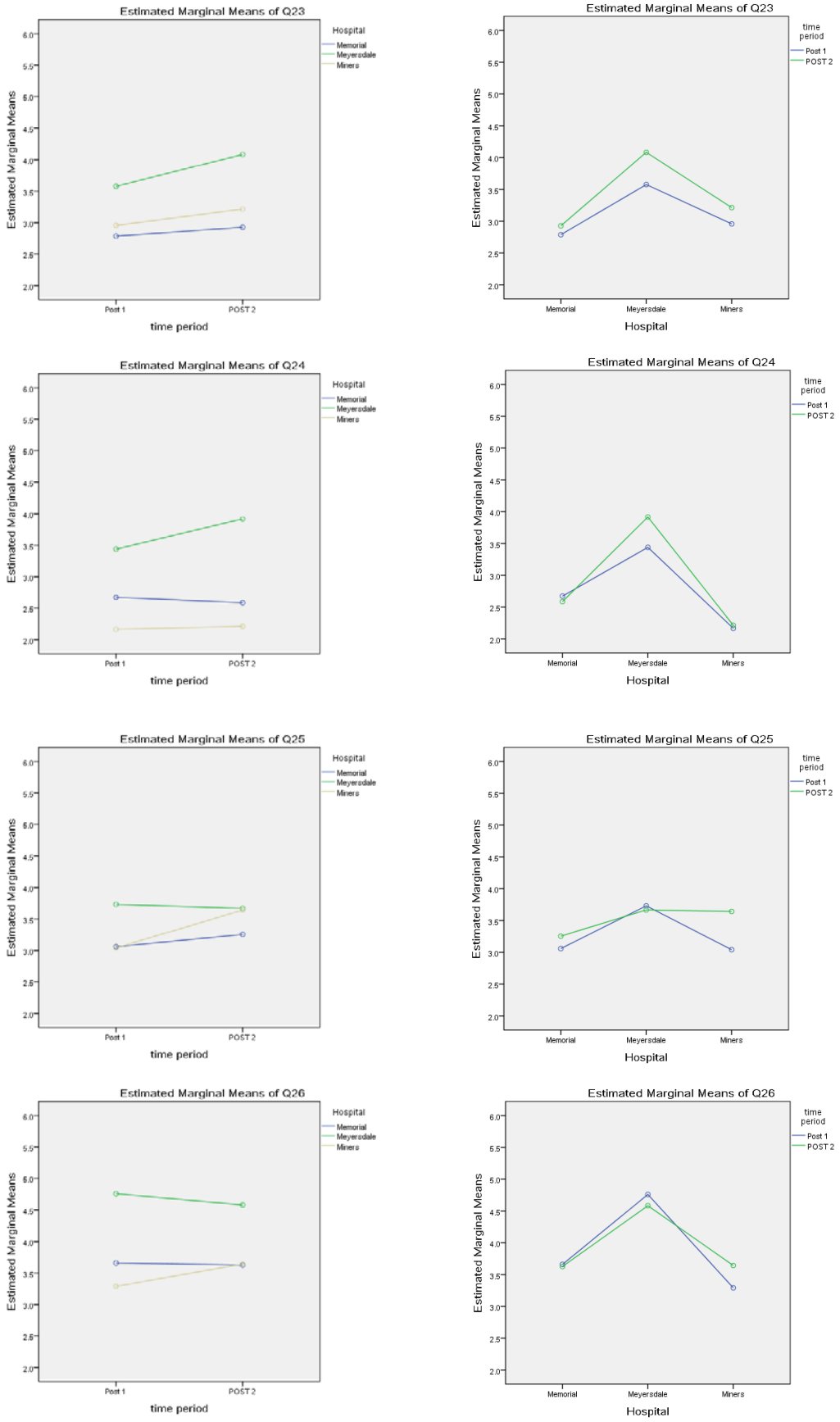



**Figure 26. Estimated Marginal Means for Stated Questions.**

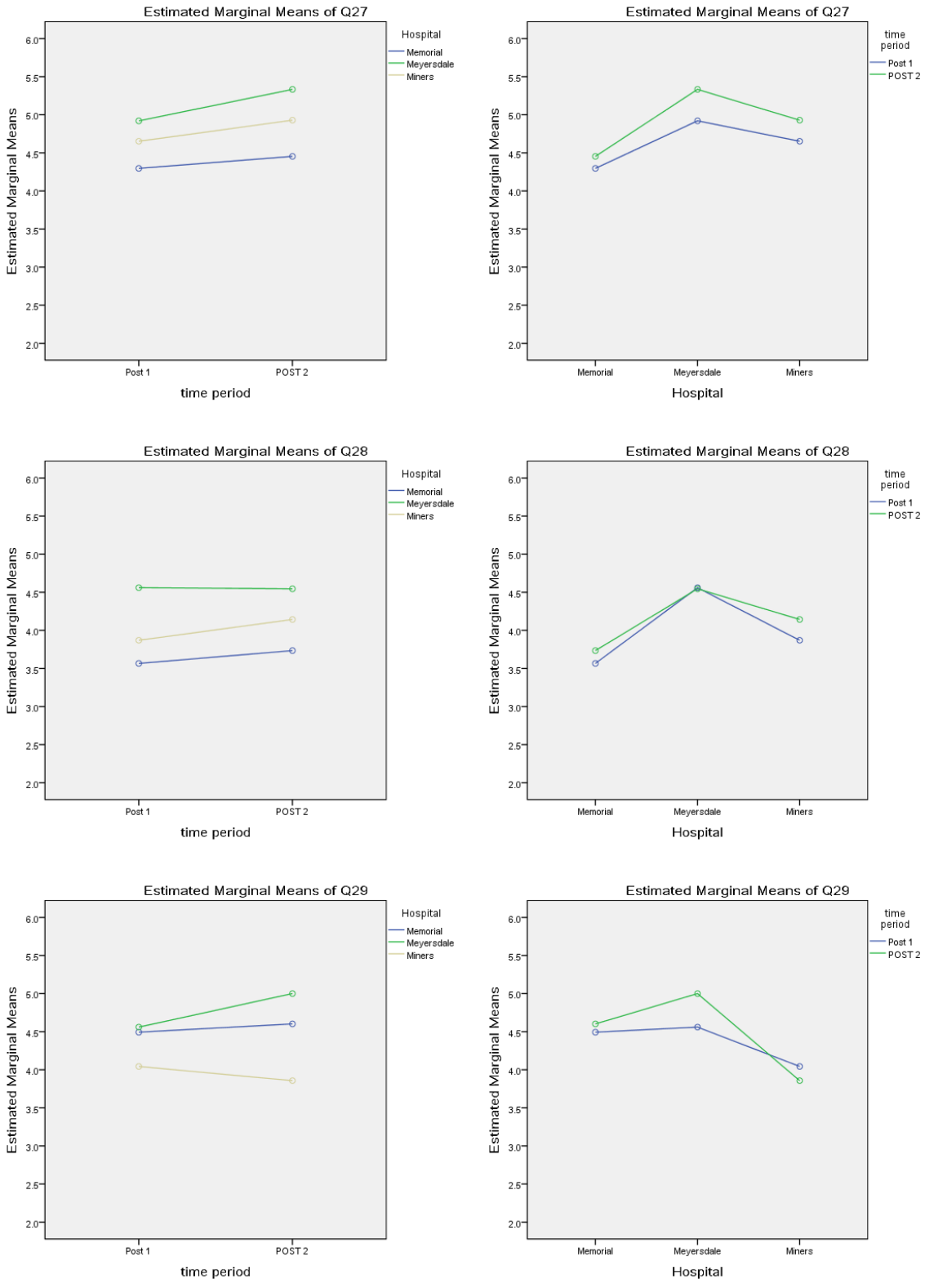



**Figure 27. Estimated Marginal Means of Stated Questions II.**

Question thirty, Q30, with the following Likert response scale and corresponding numerical quantification was analyzed using a two-way ANOVA. No interaction effect was found between the two factors, location and time period. The Location main effect was not significant. The time period main effect was statistically significant, F(2,849) = 4.233, p = .015.

**Q30. Overall, how satisfied are you with the current medication administration system?**

| **Completely Dissatisfied** | | | | **Neither satisfied nor dissatisfied** | | | | | ***Completely Satisfied*** |
|---|---|---|---|---|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |

The differences in overall satisfaction between levels of time period (baseline, post 1, post 2) collapsed across location (MMC, MYMC, MIMC) was statistically significant at an alpha level of .05. The contrasts between baseline and post 1 along with those between baseline and post 2 were significant, p = .016 and .007 respectively. Figure 28 on the left reveals that the MYMC location likely contributes most to this finding. All locations show a trend of decreasing satisfaction. The trends of MMC and MIMC are more similar to each other than to that of MYMC. MMC and MIMC began slightly satisfied and finished close to a neutral valuation; whereas MYMC began slightly satisfied and finished slightly dissatisfied.

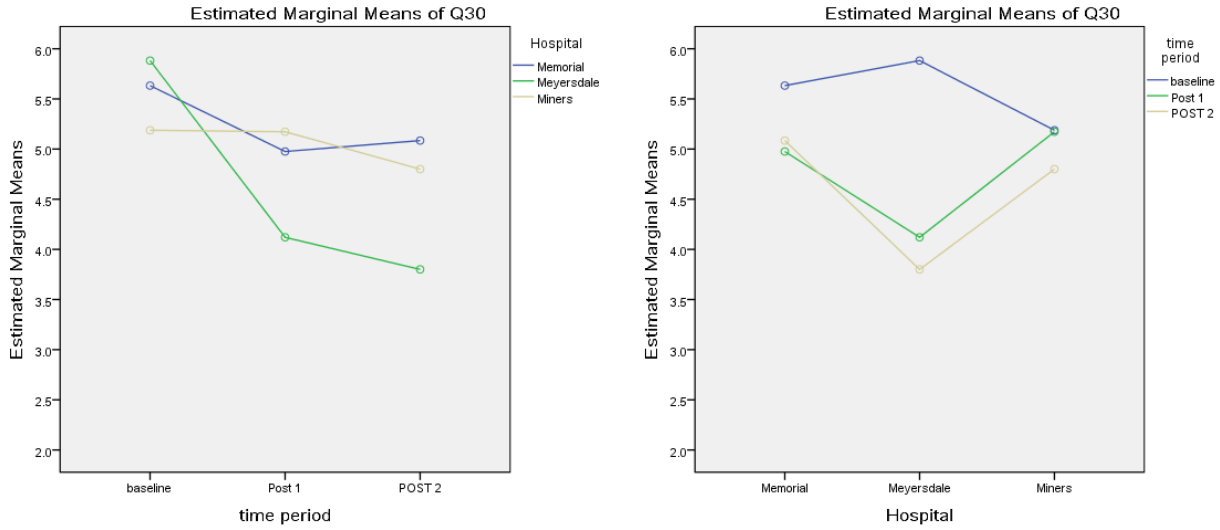



**Figure 28. Estimated Marginal Means of Questions 30 by Time Period and Hospital.**

## Conclusion

A strong sample size (n > 900) was received from Nursing staff at MMC, MYMC and MIMC during one PRE-BCMA distribution and two POST-BCMA distributions (3 and 6 months post) of the Medication Administration System Survey – Nurses' Assessment Survey (MAS-NAS). The primary question related to satisfaction of the medication administration system did have a slight negative change from PRE to POST but the overall opinion across time periods is close to 5 (neutral feeling) on the 1-10 scale. MYMC, with a much smaller sample size, had a greater negative trend than MMC whereas MIMC was more similar to

MMC. Despite the overall drop in satisfaction of the BCMA system, a majority of nurses (>70%) agreed positively with the perception that the system was effective in reducing and preventing medication errors. Demographics of the sample size should be considered. With an average of 10.5 years of nursing experience (56 nurses with over 20 years of experience) and >80% of respondents never have used a BCMA system before, it can be safely assumed that staff nurses as a whole did not positively support the change from a satisfaction perspective during the evaluation periods.

### 1.2.9 School of Nursing Satisfaction Survey (Re-budget Item)

An abbreviated MAS-NAS baseline survey was distributed to all nursing students on December 3, 2012 (Appendix F). A strong response was received (n=102) before the survey was closed on December 14, 2012. Survey respondents that followed instructions received a token incentive for completing a valid survey. Five respondents stated in written comments that they would like improved access to medication carts for training purposes.

A total of 87 Conemaugh nursing students completed the POST BCMA survey during April and May of 2013, which included a good balance between 1st and 2nd year students. The following select questions suggest a positive change in access to the system after additional medication carts were made available and a favorable opinion of the BCMA system on improving patient safety.

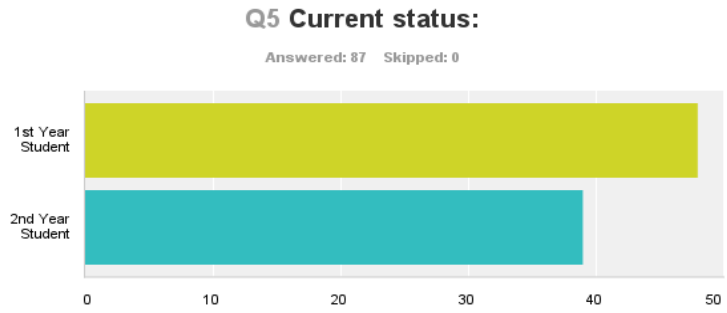



**Figure 29. Current Status of Nursing Student.**

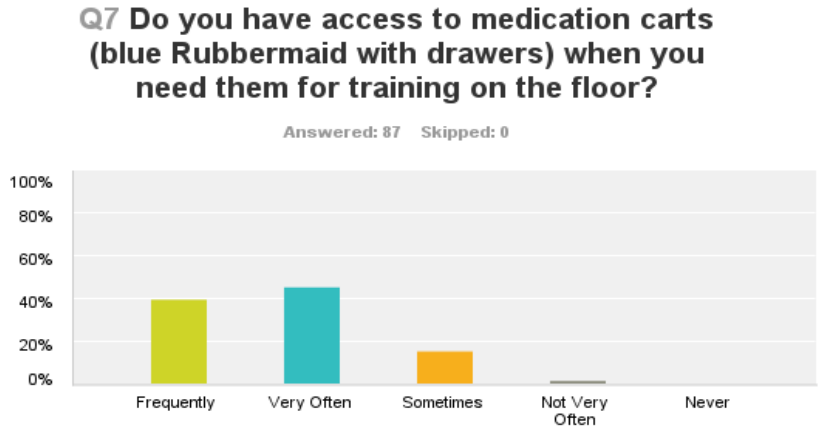



**Figure 30. Access to Medication Carts (POST).**

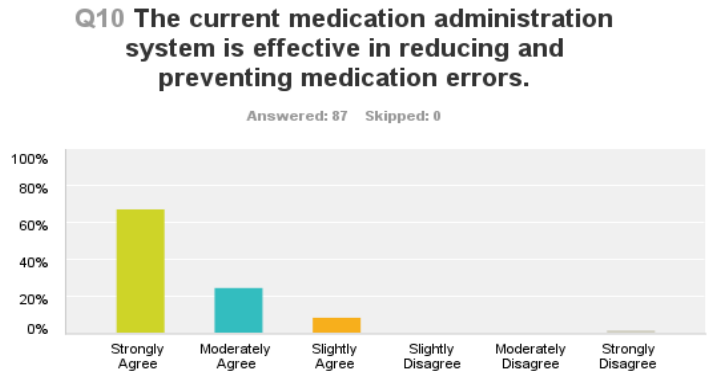



**Figure 31. Impact on Preventing Medication Errors.**

Nursing students did not suggest any real change in patient safety deduced from the same median and mode for both time periods (Strongly Agree). Overall, they believe the BCMA system is effective is preventing medication errors but additional system usage did not change their opinion.

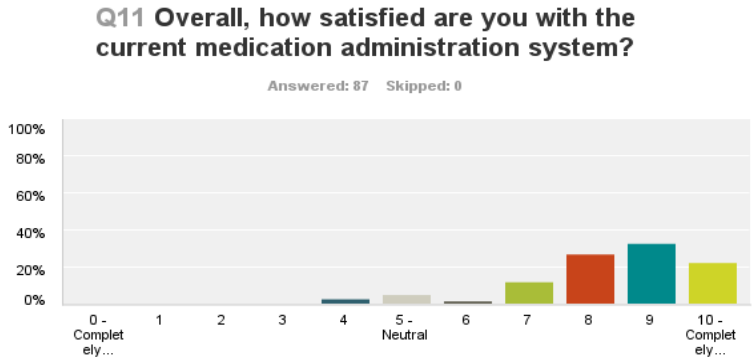



**Figure 32. Overall Satisfaction of BCMA System.**

Overall satisfaction did not change over time with a median of 9.0 for both PRE and POST data sets. Nursing students have a favorable opinion of the BCMA system and likely cannot compare historically to the manual medication administration system previously used at Conemaugh.

## Conclusion

A strong sample size (n >180) was received from Conemaugh nursing students before and after the purchase and deployment of additional blue Rubbermaid medication carts to the School of Nursing to the distribution of an abbreviated MAS-NAS. The sample had a nice balance between first and second year students. Comparison of mean statistics between PRE (Sometimes – 2.75) and POST (Very Often – 3.21) results suggest a positive change occurred and ultimately a favorable training experience was created through improved access to the BCMA system.

### 1.2.10 Nursing Workflow/Time & Motion Study – All Sites

Study team personnel physically shadowed the clinician (RN or LPN) during multiple contiguous four-hour blocks of time during their work shift before (PRE) and after (POST) BCMA/eMAR implementation at all sites (MMC, MYMC, and MIMC). Prior to shadowing, the study team met with the clinicians to confirm the completeness and accuracy of the activities listed on the time and motion tool, the activity identification (AID) index, as sufficient representations of the corresponding actual workday activities. Effort was made to obtain a representative data sample by varying the clinician, the clinical unit (e.g. patient type and load), and time of day of the observation. As used, the time and motion tool consisted of 35 unique activities (AIDs). The implementation of BCMA/eMAR was expected to alter nursing procedures particularly at the task (activity) level. Some tasks were unaffected, some were expanded in scope, while others were reduced, and a few were eliminated. These procedural adjustments introduced variation from PRE to POST into some AIDs. The confounding influence of this variation was managed first through the defining of the AIDs so as to minimize the replacements from PRE to POST shadowing, and second by the categorization of the AIDs into work processes. The presumption being that the magnitude of any change at the AID level would not be so large as to change the process category of that activity. For analysis, each AID was placed into one of ten processes (PIDs); these processes represent collections of activities of related function, see Table 21. A PID is a stratification of the data by aggregating every instance of specific AIDs of related-function. Most PIDs contain multiple AIDs.

Every time study personnel observed and recorded an activity, it represented an instance of that AID. When the observed task was not represented by a predefined AID, that instance was recorded using the 'other' AID. The time and motion tool recorded the elapsed time per each instance of an AID. The sum of the duration (time) of all the instances of AIDs yielded a total observation time per time period. Similarly, the sum of the time per instance of the AIDs assigned to a PID yielded the total time per PID. The total time of shadowing PRE and POST for each location was nearly equal (Table 20). A normalization procedure was therefore applied to allow for legitimate direct comparisons of the data between time periods (by location). The total time for each location by time period (PRE and POST) was calculated and used to normalize (rescale) the data. The elapsed time for each instance of AID was divided by the total time for each location. The normalized data was then multiplied by 100 to yield the outcome variable of analysis, dTime_normd_pct.

**Total Time**
**Per Location and Time Period**

| | **MMC** | | | **MYMC** | | | **MIMC** | | |
|---|---|---|---|---|---|---|---|---|---|
| **Time Period** | hh:mm:ss | seconds | observations | hh:mm:ss | seconds | observations | hh:mm:ss | seconds | observations |
| PRE | 105:22:10 | *379,330* | 26 | 3:55:00 | *14,100* | 1 | 4:04:46 | *14,868* | 1 |
| POST | 104:53:31 | *377,611* | 26 | 4:15:58 | *15,358* | 1 | 3:59:46 | *14,386* | 1 |
| difference between time periods | 0:28:39 | | | 0:20:58 | | | 0:08:02 | | |

**Table 20. Nurse Shadowing Total Time by Location.**

This derived variable represents the percent of total time (per location per time period) for each instance of AID.

The between time period analysis, PRE vs. POST, for each location was applied on the following levels of stratification:

1. process (PID) and
   a. BCMA/eMAR (and related) activities
2. individual activity (AID)
3. intra-location geography by PID

The BCMA/eMAR level of analysis focuses on a subset of AIDs of PID 1; specifically AIDs 4, 5, 14, and 24. This level of analysis was necessary since AIDs 4, 5, and 14 were directly impacted (replaced) by AID 24 (BCMA/eMAR, POST only). In fact, the data showed that AIDs 4, 5, and 14 were not used during the POST shadowing and therefore effectively eliminated. The tasks represented were now being accomplished by the BCMA/eMAR systems. Therefore, this analysis compared the aggregation of 4, 5, and 14 in the PRE with all instances of AID 24 (POST).

| Activity ID (AID) | Process ID (PID) | Process Description | Individual Activity Description | Process ID |
|---|---|---|---|---|
| 1 | 1 | MED administration | Passing medications | 1 |
| 2 | | | Hang IV fluids | 1 |
| 3 | | | Retrieve meds from Pyxis, bins, or tube | 1 |
| *4* | | | Compare physical med to paper MAR | 1 |
| *5* | | | Confirm "Five Rights" | 1 |
| 7 | | | Passing IM/Subq meds | 1 |
| 8 | | | Passing transdermal meds | 1 |
| 9 | | | Stock or Retrieve from MED cart | 1 |
| *14* | | | Transcibe med orders - paper MAR | 1 |
| ***24*** | | | ***eMAR*** | 1 |
| 11 | 2 | computer charting | SCANning | 2 |
| 19 | | | review lab/rad results - computer | 2 |
| 21 | | | Admissions | 2 |
| 22 | | | Discharges | 2 |
| 23 | | | Standard | 2 |
| 51 | 3 | patient-related activities | Pt assessment-e.g. vitals | 3 |
| 52 | | | Physician Rounding-listening | 3 |
| 53 | | | Pt assistance-e.g. meals | 3 |
| 64 | 4 | talking in-person to::> | Colleague/Staff for Pt. | 4 |
| 66 | | | verbal report-out with nurses | 4 |
| 71 | | | Patient/Family | 4 |
| 76 | 5 | MED-related interruptions ONLY | | 5 |
| 73 | 6 | waiting | waiting for MED cart | 6 |
| 74 | | | waiting for Pxyis access | 6 |
| 72 | 7 | walking inside | | 7 |
| 79 | 8 | Phone | Patient (patient family) | 8 |
| 80 | | | Doctor | 8 |
| 81 | | | Nurse | 8 |
| 82 | | | Pharmacy | 8 |
| 85 | | | misc. | 8 |
| 20 | 9 | Paper | fax, copy | 11 |
| 55 | | | check or write PAPER charts | 11 |
| 56 | | | review lab/rad results - PAPER | 11 |
| 70 | | | Nurse's note for charting later | 11 |
| 62 | 10 | personal time-Any | | 10 |

**Table 21. Table 14. Nurse Shadowing: Process (PID) Details .**

The AID analysis level is the aggregation of every instance of each AID used to create the PIDs. Intra-location geography is a stratification by unit within MMC, namely:

- A9 = Ashman/Rose Pavilion, clinical unit 9, Ashman section
- R10 = Ashman/Rose Pavilion, clinical unit 10, Rose section
- GS5 = Good Samaritan Building, clinical unit 5
- MS7 = Medical Surgical clinical unit 7

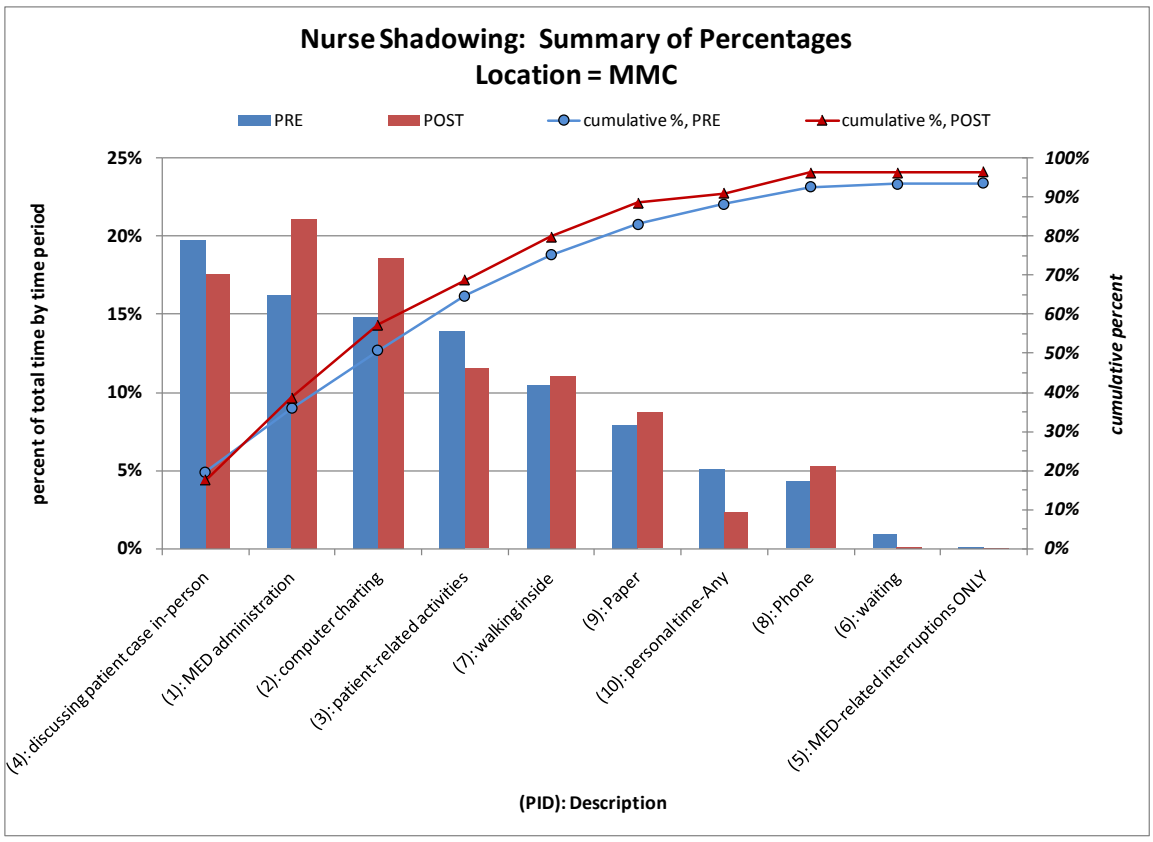
These clinical areas were chosen as a representative sample of MMC based upon physical layout and patient composition. Given the size of MYMC and MIMC (20-bed rural critical access hospital and thirty bed facility respectively), the intra-location geography concept is not applicable.

ANOVA analyses, between time period (PRE vs. POST), was accomplished for each location separately. Applying an ANOVA analysis to dTime_normd_pct provides the most effective manner in which to simultaneously account for both intrinsic characteristics of this dataset, sum of time and frequency, that influence the quantification of efficiency (productivity) and gross system changes. Analysis of the mean of dTime_normd_pct accounts for both components and provides directly comparable results across time periods. A family-wise alpha = 0.05 was set as the criteria for statistical significance.

MMC

The time and motion POST data collection occurred (January – April 2012) at MMC. This data was compared to the observation in the PRE period (May - June 2011) with the following results.

The statistically significant finding on the BCMA/eMAR level implies that the implementation is being utilized as intended. Also, since no PID individually and only one AID individually, which likely would not be influenced by BCMA implementation, showed statistical significance, the results imply that the implementation of bar coded medication administration did not positively or negatively impact the efficiency of the nursing workflow at MMC as analyzed. Please refer to Figure 33 and Table 22 and Table 23 for details.




Note: Cumulative percent does not reach 100% because the "Other" PID is not graphed since these activities are not germane to the analyses.

**Figure 33. Nurse Shadowing: Summary of Percentages, MMC.**

MMC PRE (N = 26 observations - RN):

| *Nurse Shadowing: Study Time Period = PRE, Location = MMC* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Processes ranked by Total Time per PID** | | | | | | | **PID ranked by Count** | | |
| ***PID*** | *cumulative time, hh:mm:ss* | *cumulative % of time* | % of Total Time per PID | **Total Time / PID, hh:mm:ss** | ***PID*** | | **PID** | **Count of Activity IDs** | avg. time / AID, hh:mm:ss |
| ***4*** | 20:48:13 | 19.7% | 19.7% | 20:48:13 | ***4*** | | 4 | 1290 | 0:00:58 |
| ***1*** | 37:50:29 | 35.9% | 16.2% | 17:02:16 | ***1*** | | 7 | 1217 | 0:00:33 |
| ***2*** | 53:28:41 | 50.8% | 14.8% | 15:38:12 | ***2*** | | 1 | 987 | 0:01:02 |
| ***3*** | 68:09:45 | 64.7% | 13.9% | 14:41:04 | ***3*** | | 9 | 600 | 0:00:50 |
| ***7*** | 79:14:10 | 75.2% | 10.5% | 11:04:25 | ***7*** | | 3 | 559 | 0:01:35 |
| ***9*** | 87:35:16 | 83.1% | 7.9% | 8:21:06 | ***9*** | | 2 | 252 | 0:03:43 |
| ***10*** | 92:57:44 | 88.2% | 5.1% | 5:22:28 | ***10*** | | 8 | 227 | 0:01:12 |
| ***8*** | 97:30:48 | 92.5% | 4.3% | 4:33:04 | ***8*** | | 10 | 90 | 0:03:35 |
| ***6*** | 98:30:09 | 93.5% | 0.9% | 0:59:21 | ***6*** | | 6 | 51 | 0:01:10 |
| ***5*** | 98:37:32 | 93.6% | 0.1% | 0:07:23 | ***5*** | | 5 | 13 | 0:00:34 |

**Table 22. CONEMAUGH PRE: Details by Process.**

MMC POST (N = 26 observations - RN):

| *Nurse Shadowing: Study Time Period = POST, Location = MMC* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Processes ranked by Total Time per PID** | | | | | | | **PID ranked by Count** | | |
| ***PID*** | *cumulative time, hh:mm:ss* | *cumulative % of time* | % of Total Time per PID | **Total Time / PID, hh:mm:ss** | ***PID*** | | **PID** | **Count of Activity IDs** | avg. time / AID, hh:mm:ss |
| ***1*** | 22:10:21 | 21.1% | 21.1% | 22:10:21 | ***1*** | | 7 | 1261 | 0:00:33 |
| ***2*** | 41:42:02 | 39.8% | 18.6% | 19:31:41 | ***2*** | | 1 | 1249 | 0:01:04 |
| ***4*** | 60:07:50 | 57.3% | 17.6% | 18:25:48 | ***4*** | | 4 | 1109 | 0:01:00 |
| ***3*** | 72:12:12 | 68.8% | 11.5% | 12:04:22 | ***3*** | | 9 | 598 | 0:00:55 |
| ***7*** | 83:46:53 | 79.9% | 11.0% | 11:34:41 | ***7*** | | 3 | 491 | 0:01:29 |
| ***9*** | 92:56:34 | 88.6% | 8.7% | 9:09:41 | ***9*** | | 2 | 363 | 0:03:14 |
| ***8*** | 98:28:14 | 93.9% | 5.3% | 5:31:40 | ***8*** | | 8 | 221 | 0:01:30 |
| ***10*** | 100:57:21 | 96.2% | 2.4% | 2:29:07 | ***10*** | | 10 | 39 | 0:03:49 |
| ***6*** | 101:05:17 | 96.4% | 0.1% | 0:07:56 | ***6*** | | 6 | 8 | 0:00:59 |
| ***5*** | 101:07:23 | 96.4% | 0.0% | 0:02:06 | ***5*** | | 5 | 3 | 0:00:42 |

**Table 23. MMC POST: Details by Process.**

| PRE vs POST | | | PID | $n_{,PRE}$ | $n_{,POST}$ | p-value | Change of the $mean_{POST}$ relative to that of the PRE |
|---|---|---|---|---|---|---|---|
| PIDs, individually | | | No statistical significance was found. | | | | |
| BCMA/eMAR | | | 1 (subset of) | 432 | 681 | < 0.0005 | Increase |
| Intra-location geography | by PID | A9 | 1 | 475 | 512 | 0.013 | Increase |
| | | | 2 | 124 | 182 | 0.005 | Decrease |
| | | GS5 | No statistical significance was found. | | | | |
| | | MS7 | 4 | 269 | 264 | 0.045 | Decrease |
| | | | 7 | 229 | 284 | 0.027 | Decrease |
| | | R10 | 1 | 270 | 342 | 0.009 | Increase |
| AIDs, individually | | AID 3 | 1 | 238 | 179 | < 0.0005 | Decrease |

**Table 24. Summary of Statistical Findings - MMC.**

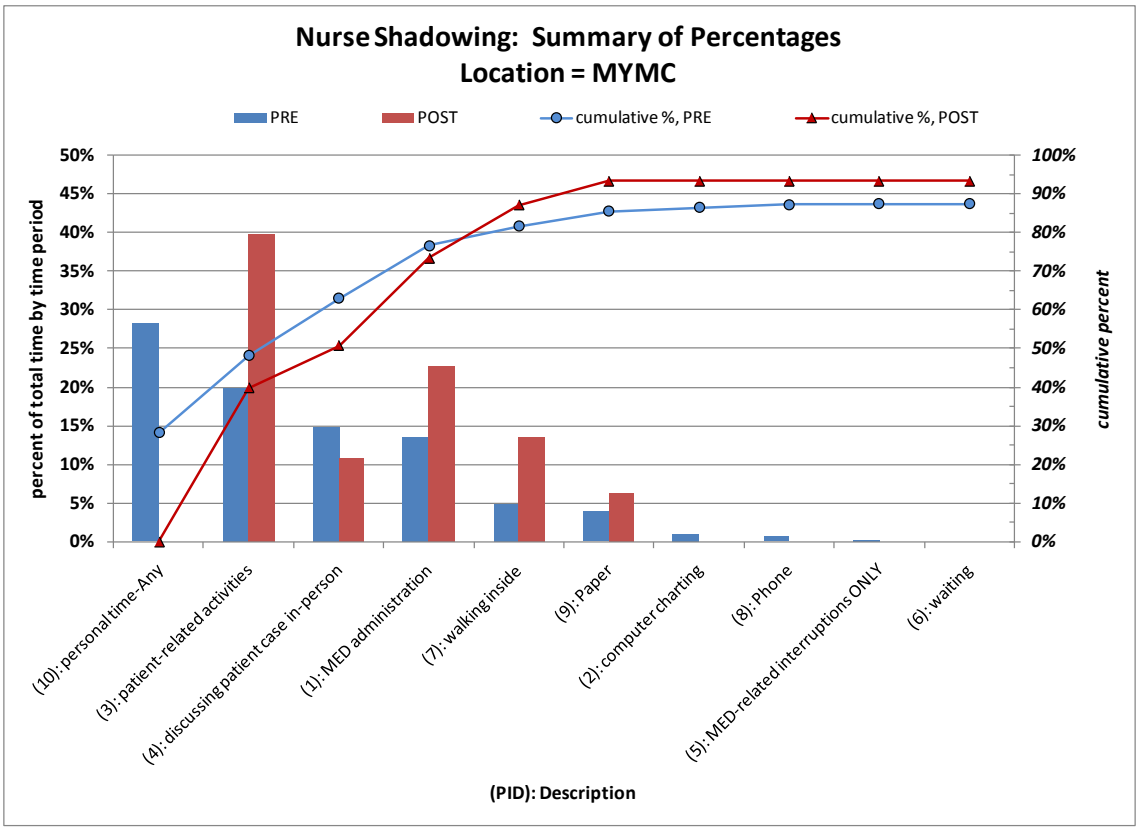
Also, for MMC, analyses were conducted on average daily census (ADC), case mix index (CMI) and between intra-location geography. PRE was compared with POST. Given the sample size for the PRE time period, Mann-Whitney test was used. No statistical significance was found overall for the analysis

by time period. The data set was stratified by intra-location geography and repeated. No statistical significance was found. The between intra-location geography ANOVA produced a significant contrast only between A9 and GS5 (p-value = 0.029) indicating that these two clinical units differ from each other on dTime_normd_pct. No evidence was found to imply that this result impacted the conclusions drawn overall.

MYMC

The time and motion POST data collection occurred (August 2012) at MYMC. This data was compared to the observation in the PRE period (June 2011) with the following results.

Statistical significance was found for two groupings, 'MED administration' and 'Talking in-person', but no individual activities. Statistical significance was found for BCMA/eMAR level as well, implying that the implementation is being successfully utilized as intended. The findings must be viewed with caution since the data contains observations from only one clinician for one four-hour time period, which is insufficient to be a representative sample; an unavoidable consequence of the typically low patient census at this location. If the significance would hold for a more representative sample, the implication could be that BCMA has some influence at MYMC. Please refer to Figure 34 and Table **25** and Table 26 and for details.




Note: Cumulative percent does not reach 100% because the "Other" PID is not graphed since these activities are not germane to the analyses.

**Figure 34. Nurse Shadowing: Summary of Percentages, MYMC.**

MYMC PRE (N = 1 observation - LPN):

| *Nurse Shadowing: Study Time Period = PRE, Location = MYMC* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Processes ranked by Total Time per PID** | | | | | | | **PID ranked by Count** | | |
| ***PID*** | *cumulative time, hh:mm:ss* | *cumulative % of time* | % of Total Time per PID | **Total Time / PID, hh:mm:ss** | ***PID*** | | **PID** | **Count of Activity IDs** | avg. time / AID, hh:mm:ss |
| ***10*** | 1:06:28 | 28.3% | 28.3% | 1:06:28 | ***10*** | | 1 | 35 | 0:00:55 |
| ***3*** | 1:53:05 | 48.1% | 19.8% | 0:46:37 | ***3*** | | 7 | 17 | 0:00:41 |
| ***4*** | 2:27:58 | 63.0% | 14.8% | 0:34:53 | ***4*** | | 4 | 16 | 0:02:11 |
| ***1*** | 3:00:04 | 76.6% | 13.7% | 0:32:06 | ***1*** | | 3 | 7 | 0:06:40 |
| ***7*** | 3:11:43 | 81.6% | 5.0% | 0:11:39 | ***7*** | | 10 | 6 | 0:11:05 |
| ***9*** | 3:20:48 | 85.4% | 3.9% | 0:09:05 | ***9*** | | 9 | 5 | 0:01:49 |
| ***2*** | 3:23:09 | 86.4% | 1.0% | 0:02:21 | ***2*** | | 8 | 2 | 0:00:54 |
| ***8*** | 3:24:57 | 87.2% | 0.8% | 0:01:48 | ***8*** | | 2 | 1 | 0:02:21 |
| ***5*** | 3:25:23 | 87.4% | 0.2% | 0:00:26 | ***5*** | | 5 | 1 | 0:00:26 |
| ***6*** | 3:25:23 | 87.4% | 0.0% | 0:00:00 | ***6*** | | 6 | 0 | |

**Table 25. MYMC PRE: Details by Process.**

MYMC POST (N = 1 observation - LPN):

| *Nurse Shadowing: Study Time Period = POST, Location = MYMC* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Processes ranked by Total Time per PID** | | | | | | | **PID ranked by Count** | | |
| ***PID*** | *cumulative time, hh:mm:ss* | *cumulative % of time* | % of Total Time per PID | **Total Time / PID, hh:mm:ss** | ***PID*** | | **PID** | **Count of Activity IDs** | avg. time / AID, hh:mm:ss |
| ***3*** | 1:42:04 | 39.9% | 39.9% | 1:42:04 | ***3*** | | 7 | 44 | 0:00:48 |
| ***1*** | 2:40:13 | 62.6% | 22.7% | 0:58:09 | ***1*** | | 4 | 28 | 0:00:59 |
| ***7*** | 3:15:08 | 76.2% | 13.6% | 0:34:55 | ***7*** | | 1 | 22 | 0:02:39 |
| ***4*** | 3:42:51 | 87.1% | 10.8% | 0:27:43 | ***4*** | | 3 | 10 | 0:10:12 |
| ***9*** | 3:58:57 | 93.4% | 6.3% | 0:16:06 | ***9*** | | 9 | 4 | 0:04:01 |
| ***2*** | 3:58:57 | 93.4% | 0.0% | 0:00:00 | ***2*** | | 2 | 0 | |
| ***5*** | 3:58:57 | 93.4% | 0.0% | 0:00:00 | ***5*** | | 5 | 0 | |
| ***6*** | 3:58:57 | 93.4% | 0.0% | 0:00:00 | ***6*** | | 6 | 0 | |
| ***8*** | 3:58:57 | 93.4% | 0.0% | 0:00:00 | ***8*** | | 8 | 0 | |
| ***10*** | 3:58:57 | 93.4% | 0.0% | 0:00:00 | ***10*** | | 10 | 0 | |

**Table 26. MYMC POST: Details by Process.**

| ***PRE vs POST*** | PID | $n_{,PRE}$ | $n_{,POST}$ | p-value | Change of the $mean_{POST}$ relative to that of the PRE |
|---|---|---|---|---|---|
| PIDs, individually | 1 | 35 | 22 | 0.001 | Increase |
| | 4 | 16 | 28 | 0.03 | Decrease |
| BCMA/eMAR | 1 (subset of) | 24 | 12 | < 0.0005 | Increase |
| Intra-location geography | Not Applicable | | | | |
| AIDs, individually | No statistical significance was found. | | | | |

**Table 27. Summary of Statistical Findings - MYMC.**

MIMC

The time and motion POST data collection occurred July 2014 at MIMC. This data was compared to the observation in the PRE period (May 2012) with the following results. So as to be directly comparable, the data for each time period was normalized. ANOVA was applied to each category over time period. Only the Med administration (N,pre = 72; N,post = 128) yielded statistical significance, p-value = .024. Homogeneity of variance held but normality was violated, therefore Mann-Whitney U was applied which yielded a p-value = .004. Even with appropriate application of correction for multiple tests, the reduction in time per medication administration event from PRE to POST is likely statistically significant. Of note, statistical comparison for some categories was not calculable due to very small (even zero) sample size, but nonetheless likely represent a meaningful change. Testing by individual activity was hampered by normality violations and both small and severely disparate sample sizes. Even for the few activities for which the Mann-Whitney test was feasible, no statistical significance was found. Please refer to Figure 35 and Table 28 and Table 29 for details.

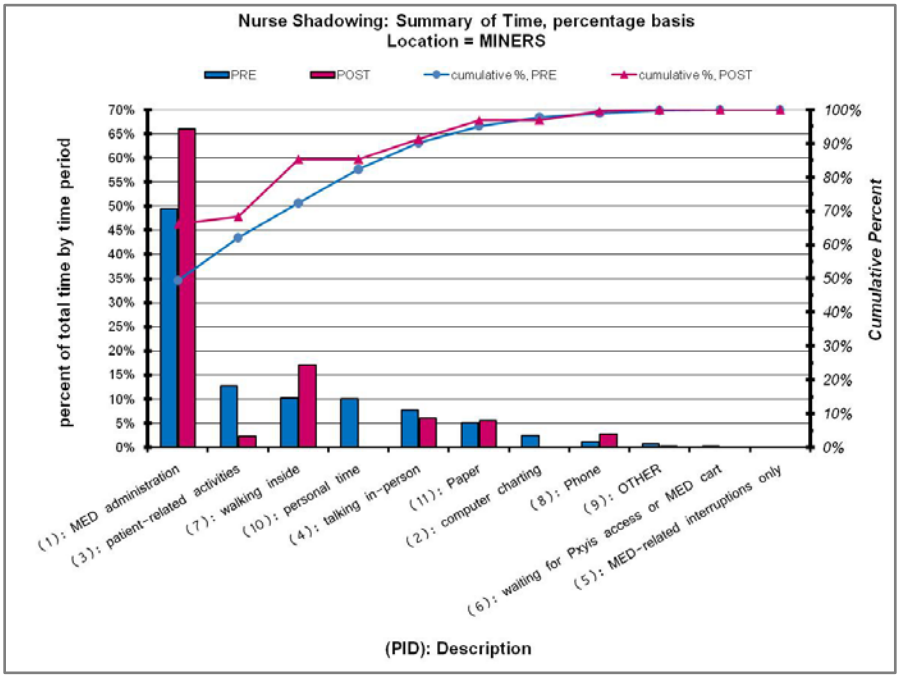



**Figure 35. Nurse Shadowing: Summary of Percentages, MIMC.**

MIMC PRE (N = 1 observation – RN):

| Nurse Shadowing: Study time Period - PRE, Location - MiMC | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Processes ranked by Total Time per PID | | | | | | | PID ranked by Count | | |
| PID | cummulative time, hh:mm:ss | cummulative time per total time, % | % of Total Time by PID | Total Time / PID, hh:mm:ss | PID | | PID | Count of Activity IDs | avg. time / AID hh:mm:ss |
| **1** | 1:59:02 | 49.5% | 49.5% | **1:59:02** | **1** | | 1 | 72 | 0:01:19 |
| **3** | 2:29:40 | 62.2% | 12.7% | **0:30:38** | **3** | | 7 | 44 | 0:03:36 |
| **7** | 2:54:12 | 72.4% | 10.2% | **0:24:32** | **7** | | 4 | 32 | 0:00:36 |
| **10** | 3:18:24 | 82.5% | 10.1% | **0:24:12** | **10** | | 11 | 16 | 0:00:45 |
| **4** | 3:37:06 | 90.3% | 7.8% | **0:18:42** | **4** | | 3 | 9 | 0:03:24 |
| **11** | 3:49:13 | 95.3% | 5.0% | **0:12:07** | **11** | | 2 | 3 | 0:02:01 |
| **2** | 3:55:17 | 97.8% | 2.5% | **0:06:04** | **2** | | 8 | 2 | 0:01:30 |
| **8** | 3:58:18 | 99.1% | 1.3% | **0:03:01** | **8** | | 9 | 2 | 0:00:51 |
| **9** | 3:59:59 | 99.8% | 0.7% | **0:01:41** | **9** | | 10 | 2 | 0:12:06 |
| **6** | 4:00:32 | 100.0% | 0.2% | **0:00:33** | **6** | | 6 | 1 | 0:00:33 |
| **5** | 4:00:32 | 100.0% | 0.0% | **0:00:00** | **5** | | 5 | 0 | |

**Table 28. MIMC PRE: Details by Process.**

MIMC POST (N = 1 observation – RN):

| Nurse Shadowing: Study time Period - POST, Location - MiMC | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Processes ranked by Total Time per PID | | | | | | | PID ranked by Count | | |
| PID | cummulative time, hh:mm:ss | cummulative time per total time, % | % of Total Time by PID | Total Time / PID, hh:mm:ss | PID | | PID | Count of Activity IDs | avg. time / AID hh:mm:ss |
| **1** | 2:36:50 | 66.1% | 66.1% | **2:36:50** | **1** | | 1 | 128 | |
| **7** | 3:17:19 | 83.2% | 17.1% | **0:40:29** | **7** | | 7 | 43 | 0:00:34 |
| **4** | 3:31:28 | 89.2% | 6.0% | **0:14:09** | **4** | | 4 | 17 | 0:00:45 |
| **11** | 3:44:45 | 94.8% | 5.6% | **0:13:17** | **11** | | 11 | 12 | 0:02:31 |
| **8** | 3:51:11 | 97.5% | 2.7% | **0:06:26** | **8** | | 3 | 4 | 0:01:19 |
| **3** | 3:56:29 | 99.7% | 2.2% | **0:05:18** | **3** | | 8 | 2 | 0:03:13 |
| **9** | 3:57:07 | 100.0% | 0.3% | **0:00:38** | **9** | | 9 | 1 | 0:00:38 |
| **2** | 3:57:07 | 100.0% | 0.0% | **0:00:00** | **2** | | 2 | 0 | |
| **5** | 3:57:07 | 100.0% | 0.0% | **0:00:00** | **5** | | 5 | 0 | |
| **6** | 3:57:07 | 100.0% | 0.0% | **0:00:00** | **6** | | 6 | 0 | |
| **10** | 3:57:07 | 100.0% | 0.0% | **0:00:00** | **10** | | 10 | 0 | |

**Table 29. MIMC POST: Details by Process.**

**Nursing Time and Motion Summary**

Similar to other academic medical centers, BCMA was not associated with an increase in the amount of time spent on medication administration-related activities (Poon EG 2008 Dec). Small differences were noted on specific clinical units, and medication administration efficiencies could therefore be somewhat affected by patient acuity. Significant time differentials were not specifically noted.

AHRQ hospitals reported no long-term impacts on nurse efficiency. Though BCMA does not appear to increase workload, realistic expectation should be set with nursing staff that it is not a time-saving technology (Hook JM 2008). Patient safety effects should be self-evident, but BCMA work arounds continually evolve.

**Overall Workflow Summary Indications**

In agreement with the Agency for Healthcare Research and Quality's (AHRQ) (Agency for Healthcare Research & Quality n.d.) discussion on communication and workflow regarding bar coded medication administration, implementing BCMA required workflow modifications for not only pharmacy, but also nursing, and other stakeholders. Changes in culture, attitudes, and practice, were not only a necessity, but evident in both realizing and achieving the benefits of this technology.

Redesigning the medication administration process as part of implementing BCMA required increased collaboration and communication among pharmacy and nursing staff. The workflow redesign forced those involved to confront and re-define longstanding perceptions surrounding the roles and responsibilities of each party in the medication administration process. Differing perspectives and perceptions have likely changed before, during, and after BCMA implementation and will continue to evolve.

While the implementation of BCMA was expected to impact patient safety but is outside of the discussion for workflow, results in terms of time savings were not achieved, similar to results noted in the literature. CHS, similarly to BCMA findings reported by the AHRQ, yielded no net impact on the efficiency of nursing staff and did possibly create additional work for pharmacy staff.

While the benefits of BCMA are realized, human factors, along with basic system functionality and organizational infrastructure, need to be given careful consideration before during and after implementation. Moreover, the complex and dynamic nature of care processes and diverse types of system users can widen the gap between the system-intended process and the actual work process. Systems implemented without consideration of existing work flows and user adaptation can provoke unfavorable perceptions and reluctance on the systems and theses can be major causes for non-compliance behaviors and workarounds (Holden RJ 2011) (Yang, et al. 2012) (Miller 2011) (Halbesleben JRB 2010) (Rack, Dudjak and & Wolf 2012).

Nursing and pharmacy staff cooperation/communication is essential during both medication order verification and administration. BCMA however demonstrates an improved accountability and measurement of the medication administration process. Reporting capabilities of many BCMA systems support analysis of when a medication was administered, who administered it, and whether medication information was scanned or manually entered into the system. With many hospitals, Conemaugh included, bar coding benefits at all points of medication distribution may be further realized as healthcare continues to transform and redefine itself (Wideman, ME and Anderson 2005).

### 1.2.11 Medication Error Analysis

Lewis et al. (Lewis PJ 2009) found that an average medication error rate in all prescribing orders is estimated to 7%. It is also estimated that every two admissions experience a medication error. Thirty-eight percent of preventable medication errors however, occurred at the medication administration process (Shane 2009). With such statistics, the overall impact of the BCMA system on the organization would not be complete without a medication error analysis.

*Medication Errors Type*

The research team completed intensive review of all CHS medication events as reported in the Quantros SRM event/incident reporting system. Medication events were reviewed at all CHS facilities (MMC, MYMC and MIMC). All errors that occurred within a unit/department that had not deployed BCMA technology were removed from the dataset.

Errors were examined via disposition, applicability to MIDHT, phase, and core problem (medication error) type. Level of analysis are described below and detailed in Table 30.

- *Error Disposition*: This designation was completed by Quantros SRM users and qualifies as an "actual" or "near miss."
- *Applicability to MIDHT*: The research team used both medication error type and phase to subjectively determine MIDHT Applicability (as designated as "Yes" or "No") for each error. In other words, based on the reported medication event, could the error be attributed to the BCMA technology?
- *Phase*: The phase was subjectively determined by the study team using common industry standards detailing the medication administration process. Phase identification was consistent with current literature. The MIDHT intervention primarily consisted of technology and process changes that only impacted the Dispense and Administration phases through pharmacy robotics and BCMA at the bedside.
- *Core Problem (Medication Error) Type:* This was predefined within Quantros using standardized phrases. Some of the errors were scrutinized in an attempt to determine the origination of the issue. A small percentage of these standard error types were aggregated by the study team to enable statistical testing on this variable (Table 31 below).

The influence of the MIDHT intervention on medication errors from before implementation, PRE, versus after implementation, POST, was investigated using the Pearson Chi-squared test. Fisher's Exact Test was employed as required, e.g. when the count of any cell in the crosstab being analyzed was less than 5. The ordinal variable, Study Time Period, was treated as the independent variable (IV). It has only two levels, PRE and POST, both which contained 12 months of data for each clinical unit (MMC) or site. The statistical analysis plan was comprised of two major steps:

1. Each of the following variables were treated as dependent variables and separately tested against Study Time Period. The dependent variables are as follows:

| Variable Name | Variable Type | Levels |
|---|---|---|
| Error Disposition | nominal | Near Miss |
| | | Actual |
| MIDHT Applicability | nominal | Yes |
| | | No |
| PHASE | ordinal | ORDER (1st) |
| | | PROFILE (2nd) |
| | | DISPENSE (3rd) † |
| | | ADMINISTRATION (4th) † |
| | | Other |
| Core Problem (Med. Error) Type | nominal | Please see Table 31 for a detailed listing |

**Table 30. Variable Name Description.** † Primary MIDHT intervention focus

2. If statistical significance was found for a test variable in step 1, a layered analysis by MIDHT Applicability on that variable(s) over Study Time Period was then executed. This approach allows for a more detailed investigation of change from PRE to POST by using MIDHT Applicability to stratify the variable being tested in step 2. Please note these original medication error designations were later regrouped based upon similarities between the error types.

| Core Problem (Med Error) Type | Core Problem Code |
|---|---|
| Bar Coding/Scanning Error | 1 |
| Charting Error | 2 |
| Drug Delay | 3 |
| Drug Location Issue | 4 |
| Drug Not Ordered | 5 |
| Drug Omitted | 6 |
| Drug Protocol/Policy Not Followed | 7 |
| Incorrectly Stamped Order Sheet | 8 |
| IV Related Issue | 9 |
| Medication Reconcilliation Issue | 10 |
| Order Issue | 11 |
| Order Issue/Not Entered | 12 |
| Patient Not Compliant | 13 |
| Pharmacy Profile Error | 14 |
| Pyxis Issue | 15 |
| Wrong Dose | 16 |
| Wrong Drug | 17 |
| Wrong Frequency | 18 |
| Wrong Label | 19 |
| Wrong Patient | 20 |
| Wrong Quantity | 21 |
| Wrong Route | 22 |

**Table 31. Medication Error Type Listing.**

The medication administration process is not simply the act of administering medication, but rather complex processes involving multiple steps from numerous disciplines, departments, and users. Errors can appear at one, some or even all stages between the medication order process (prescription) through the actual administration of the medication and/or possible adverse events. Though a specific error may occur prior to a patient receiving the medication, most errors are noted only once the medication is incorrectly administered at the bedside.

Medication Errors by Type – MMC

Researchers reviewed over 1,100 written incident summaries (November 2010 – January 2013) in detail and logically determined the impact on the MIDHT study using the above mentioned variables. The PRE-BCMA time period for MMC was November 2010 – October 2011. The POST-BCMA time period was from November 2011 – January 2013. An additional three months were included in the POST-BCMA period because of the phased BCMA deployment schedule at Conemaugh. The final dataset contained 630 valid cases.

Common errors, such as wrong patient, wrong drug, and wrong dose all had a somewhat neutral change from PRE to POST (Figure 36). The low sample size per error type was an issue and produced many violations of the allowable percentage of cells with a minimum expected frequency less than five.

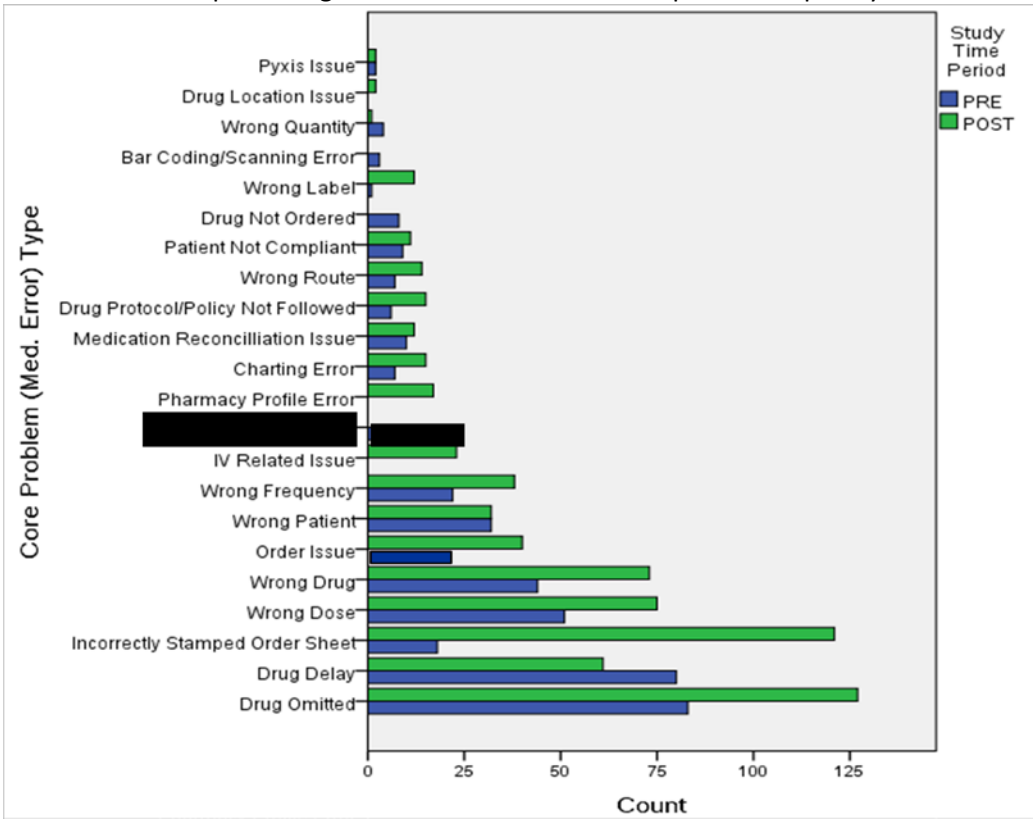



**Figure 36. Core Problem Type Counts by Period - MMC.**

The results of the stepwise analysis at MMC, which tested each of the dependent variables separately, were as follows:

| Crosstab | Chi-squared, $\chi^2$ | df | Sample size, N | p-value, asymp. Sig. (2- | |
|---|---|---|---|---|---|
| Error Disposition * Study Time Period | No statistical significance. | | | | |
| MIDHT Applicable * Study Time Period | No statistical significance. | | | | |
| PHASE * Study Time Period | 26.386 | 4 | 630 | < .0005 | |
| Core Problem (Error) Type * Study Time Period | 25.489 | 11 | 630 | .008 | *a* |

***a.*** 2 cells (8.3%) have expected count < 5. Min. expected count is 1.93.

**Table 32. Crosstab Inferential Results.**

Sidak's correction for multiple testing was applied which reduced the testwise alpha criterion to 0.017. This correction was slightly conservative in that no correlation was assumed to exist among the variables. A correlation analysis of (between) the dependent variables revealed an average correlation of 0.1, which rises slightly to 0.3 if only the statistically significant correlations are averaged. Including the 0.3 correlation into the calculation of Sidak's correction yields a testwise alpha criterion to 0.019 and corresponding critical z-value for 2 sided testing: >= 2.3407 (critical z-value for 1 sided testing: >= 2.0695). Therefore, only Phase * Study Time Period and Core Problem (Error) Type * Study Time Period crosstabs had a statistically significant result. A progression of the original designation of medication errors type can be found below in Table 33.

| Core Problem (Med Error) Type – Original | Core Problem (Med Error) Type - Revised |
|---|---|
| Bar Coding/Scanning Error | Bar Coding/Scanning Error |
| Charting Error | Charting Error |
| Drug Delay | Drug Delay |
| Drug Location Issue | Drug Location Issue |
| Drug Not Ordered | Drug Omitted |
| Drug Omitted | Duplicate Therapy |
| Drug Protocol/Policy Not Followed | Wrong Dose |
| Duplicate Therapy | Wrong Drug |
| Incorrectly Stamped Order Sheet | Wrong Frequency |
| IV Related Issue | Wrong Label |
| Medication Reconciliation Issue | Wrong Patient |
| Order Issue | Wrong Quantity |
| Patient Not Compliant | Wrong Route |
| Pharmacy Profile Error | |
| Pyxis Issue | |
| Wrong Dose | |
| Wrong Drug | |
| Wrong Frequency | |
| Wrong Label | |
| Wrong Patient | |
| Wrong Quantity | |
| Wrong Route | |

**Table 33. Progression of Medication Error Type Listing.**

These results indicated that Phase and Study Time Period are not statistically independent over the entire dataset of medication errors; therefore the differences in the distribution by phase by Study Time Period are statistically significant. Standardized residuals of the crosstab revealed that Profile for PRE and POST mainly contributed to the significant chi-square result. Collectively, this implies that the observed increase from PRE to POST is significant. Given the statistically significant result for the crosstab of Phase * Study Time Period, a more detailed analysis was performed on a stratified crosstab of Phase by MIDHT Applicability versus Study Time Period. Statistical significance was found for only MIDHT Applicability = NO for the distribution of Phase between Study Time Period [chi-sq.(4) = 29.959, p-value = < .0005].

The results indicate that the distribution of Core Problem (Error) Type differs over Study Time Period. The standardized residuals imply the following variables in Table 34 contribute to that difference:

| | **Implication regarding change from PRE to POST** |
|---|---|
| Drug Location Issue | decrease |
| Wrong Frequency | increase |

Note that the implications drawn from the Core Problem (Error) Type * Study Time Period chi-squared analysis is made regarding the distribution of errors by error type by time period.

**Table 34. Standardized Residual Results.**

Given the statistically significant result for the crosstab of Core Problem (Error) Type * Study Time Period, a more detailed analysis was performed on a stratified crosstab of Core Problem (Error) Type by MIDHT Applicability versus Study Time Period. Statistical significance was found for only MIDHT Applicability = YES for the distribution of error type by Study Time Period; however, this result is invalid because nearly 40% of the cells have an expected count of < 5. The threshold for validity is < 20%.

Either the frequency of each medication error type was so low that no significant change was detected or the error can be attributed to human error and therefore not affected between time periods. Despite the lack of statistical significance, about 60% of the error types showed a 15% or greater percent change decrease in the POST-BCMA period. Medication error types, drug delay, wrong frequency, wrong label, and wrong patient each had over a 30% reduction in errors and therefore an assumed positive impact on patient safety.

<u>Medication Errors Analysis – MMC</u>

The distribution of the severity of drug errors was also analyzed over time period. The chi-square analysis produced an invalid statistically significant result because nearly 40% of the cells had an expected count < 5. Harm score was analyzed over time period. Although no statistical significance was found, this analysis was invalid in that exactly 40% of the cells had an expected count < 5. Importantly, 90.5% PRE and 94.0% POST of the med errors were marked with a Harm Score of NONE.

Initial discussions were rooted in the possibility that reporting frequency of actual vs. near miss may differ (e.g. near miss may be reported less frequently to save time; or near miss errors may be reported more POST BCMA implementation because nurses were disgruntled/dissatisfied with the technology

and/or disruptions to their traditional workflow, PRE implementation). Some studies have reported a nearly 50% reduction in medication errors post BCMA implementation.

The distribution of the severity of drug errors was thus analyzed over time period.

It should be noted however, the culture of reporting errors had changed in the POST period, which complicated the analysis. Errors were likely reported out of frustration with the deployed BCMA system and discord between the nursing and pharmacy departments.

The chi-square analysis produced an invalid statistically significant result because nearly 40% of the cells had an expected count < 5. Harm score was analyzed over time period. Although no statistical significance was found, this analysis was invalid in that exactly 40% of the cells had an expected count < 5. Importantly, 90.5% PRE and 94.0% POST of the med errors were marked with a Harm Score of NONE.

Initial discussions were rooted in the possibility that reporting frequency of actual vs. near miss may differ (e.g. near miss may be reported less frequently to save time; or near miss errors may be reported more POST BCMA implementation because nurses were disgruntled/dissatisfied with the technology and/or disruptions to their traditional workflow, PRE implementation).

Some studies have reported a nearly 50% reduction in medication errors post BCMA implementation (K. C. Poon EG 2010) (Franklin BD 2007) (Morris FH 2009). The research team will review these studies in detail and attempt to make a one-to-one comparison between their experiences and ours to generate additional lessons learned.

The medication error rate per 1,000 doses was analyzed. Some inherent error exists in this analysis because the available dosage data was not stratified by clinical unit; therefore, matching of dosage data with medication error data by clinical unit that implemented BCMA was not possible. Presuming that this error is consistent from PRE to POST, this comparison offered additional insight into any change influenced by the MIDHT intervention. A two-group independent T-test revealed no statistical significant difference in the slight increase of the mean of the med error rate PRE (0.08) versus POST (0.09).

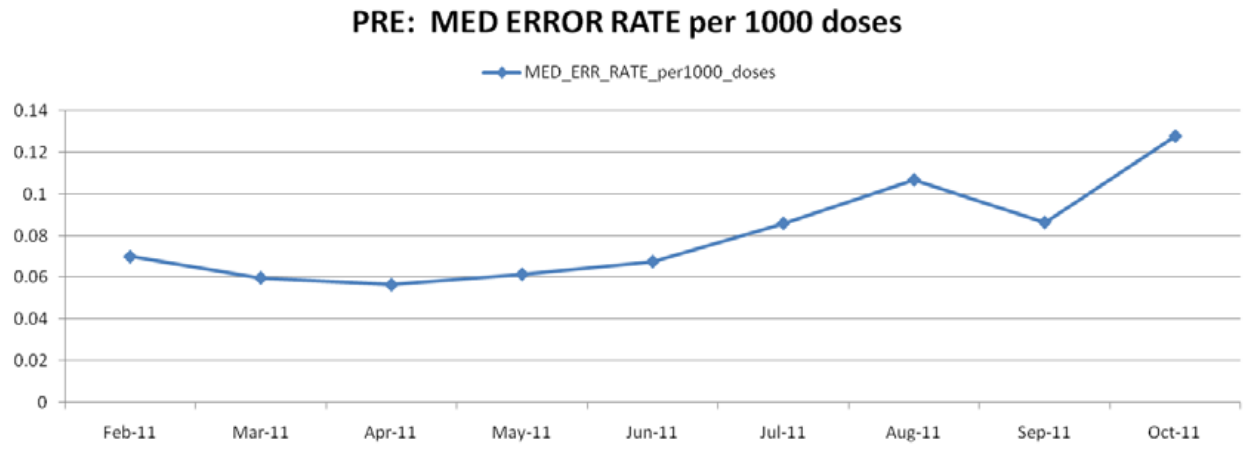



**Figure 37. MMC Medication Error Rate per 1,000 doses – PRE.**

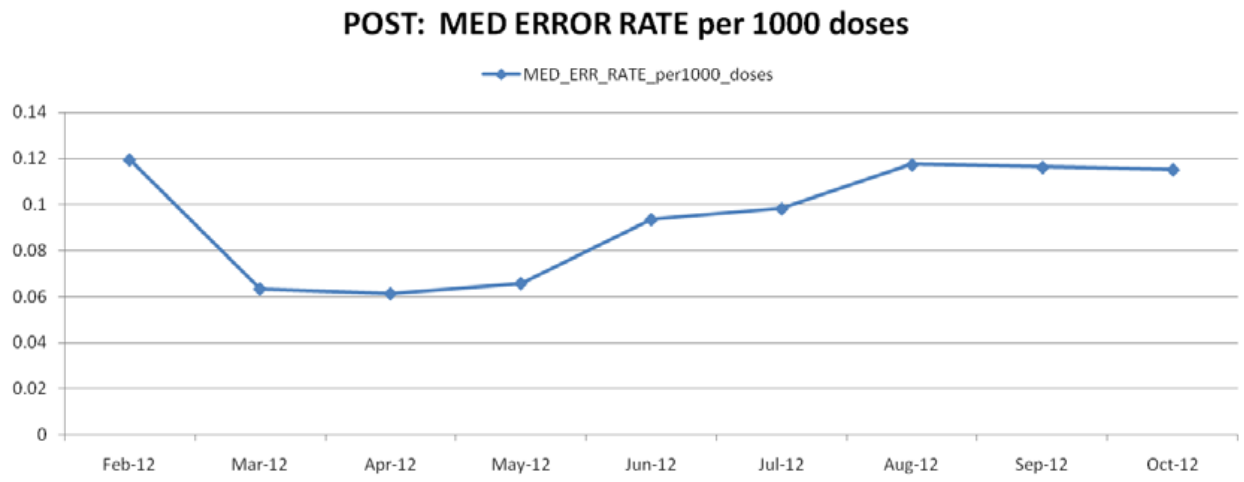



**Figure 38. MMC Medication Error Rate per 1,000 does – POST.**

Please note the timeframe plotted in Figure 37 and Figure 38 were adjusted to accommodate the phased implementation so that all clinical units are equally represented by time.
Medication errors can vary depending on the differing levels of care per clinical area. Differences between nursing units must be considered because of nurse-to-patient ratio, as well as hospital census differentials. An analysis of the distribution of medication errors by clinical unit was invalid due to the large number of clinical units involved, which produced expected cell count issues. A recent literature review study reported average baseline error frequency rates from 5.8-25.3% (1.6-27.8% if error times were excluded). [1] Wrong time errors are generally considered to be less severe. Typical reports after BCMA implementation include a 30-50% reduction in medication errors, but only when time errors are excluded.

Work-arounds performed by nursing staff must be acknowledged as a contributing factor on the medication error rates. Table 35 demonstrates manual override statistics from MMC for July through September 2013. Though these reporting statistics were not available during the study time period, inferences to the impact on medication errors by clinical unit can still be made.

| McK Adoption HARx Analytics Medication Administration | | | | | |
|---|---|---|---|---|---|
| Schedule Override Count | % with Schedule Override | Drug Warning Override Count | % with Drug Warning Override | Quantity Override Count | % with Quantity Override |
| 83 | 2.96 | 79 | 2.86 | 39 | 0.62 |

**Table 35. MMC manual overrides by type (3-month average).**

A correlation analysis between the override data above and medication errors by clinical unit was not tenable due to violations arising from sample size after stratification.

Medication error data was retrieved from Quantros for July – September 2013 and summarized for use. This analysis was continued so as to focus on clinical units cited in the literature, and to determine if high override percentages influenced medication error rates.

Medication Errors by Type – MYMC

Researchers reviewed over 80 written incident summaries (May 2011 – May 2013) in detail and logically determined the impact on the MIDHT study using the above mentioned variables. The PRE-BCMA time period for MYMC was May 2011 – April 2012. The POST-BCMA time period was from May 2012-2013. The final dataset contained 83 valid cases.

The medication error data for MYMC was analyzed by comparing pre versus post on the counts of error type, phase, harm and severity score. Due to the low sample size at this critical access hospital, many of the chi-square crosstabs violated the allowable percentage of cells with a minimum expected frequency less than five. One crosstab, phase by time period did not violate the requirement, but nonetheless, did not show a statistically significant chi-square result. Despite the lack of statistical significance, forty-five percent of the identified error types showed about a 10% or greater percent change decrease in the post period as displayed in Figure 39. Both duplicate therapy and wrong dose had a clinically significant reduction and therefore positive impact on patient safety.

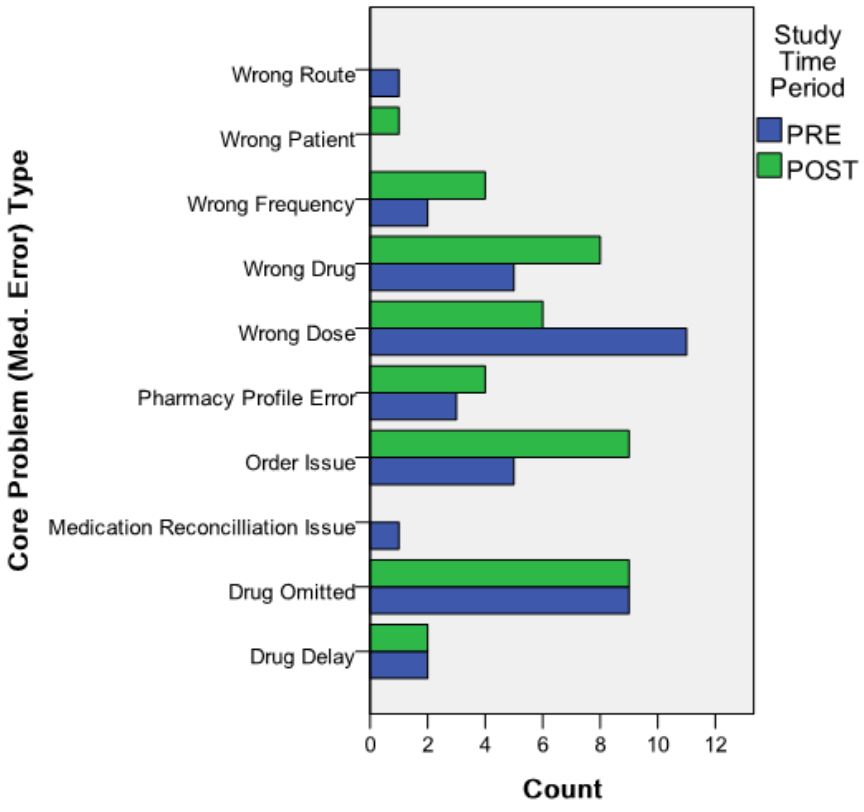



**Figure 39. Core Problem Type Counts by Period - MYMC.**

For example, wrong dose had a clinically significant reduction and positive impact on patient safety. Error types with blanks are not calculable because no data was present in the pre time period. Frequency is the difference in count between time periods.

The mean, median, and distribution of count of medication errors, doses, and medication error rate were tested using a Studentized-t, Median, and Mann-Whitney U tests respectively. Normality and homogeneity of variance held. No statistical significance was revealed. Medication error rates are shown below in Figure 40 and Figure 41:

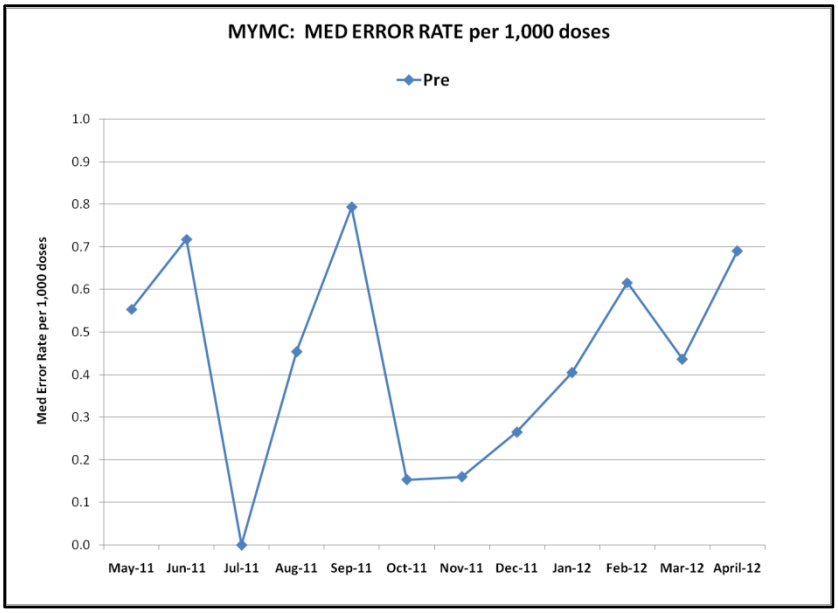



**Figure 40. MYMC Med Error Rate per 1,000 doses - PRE.**

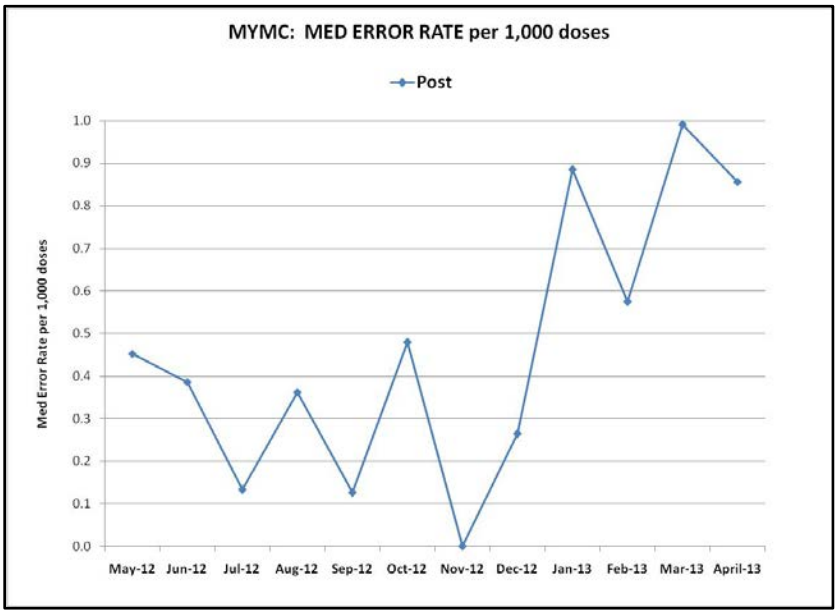



**Figure 41. MYMC Med Error Rate per 1,000 doses - POST.**

## Medication Errors by Type – MIMC

Researchers reviewed over 200 written incident summaries (May 2011 – May 2013) in detail and logically determined the impact on the MIDHT study using the above mentioned variables. The PRE-BCMA time period for MIMC was March 2013 – February 2014. The POST-BCMA time period was from March 2014 – February 2015. The final dataset contained 192 valid cases. Since the amount of medication errors was expected to be low, an entire year period is warranted for proper statistical analysis.

The dose count, med error count, and med error rate per 1,000 doses were compared over time period. Data was time-matched on month (N=12 per time period). Normality, albeit with some violation, and homoscedasticity with the exception of dose count held for all three variables for both pre and post time periods per Shapiro-Wilk and Levene's Tests respectively. A t-test revealed no statistically significant difference of means, p = .201, .125, .065 respectively.

Due to the observed normality violations, Mann-Whitney U on distribution and the Median Tests were also applied with results consistent with those of the more powerful t-test.

The Chi-squared test was utilized to test the change in med errors on time period (PRE, n = 113 vs. POST, n = 78) by MIDHT applicability (yes, no), Phase (order, profile, dispense, administration, other), and actual medication error or near miss. Only actual/near miss showed a statistically significant change, p < .0005; furthermore, the percentage within time period was also statistically significant on each level of actual/near miss. The standardized residuals indicate that more of the statistical significance lies with the near miss category, which decreased from 37% to 12% within time period while the percentage of actual medication errors increased from 63% to 89%.

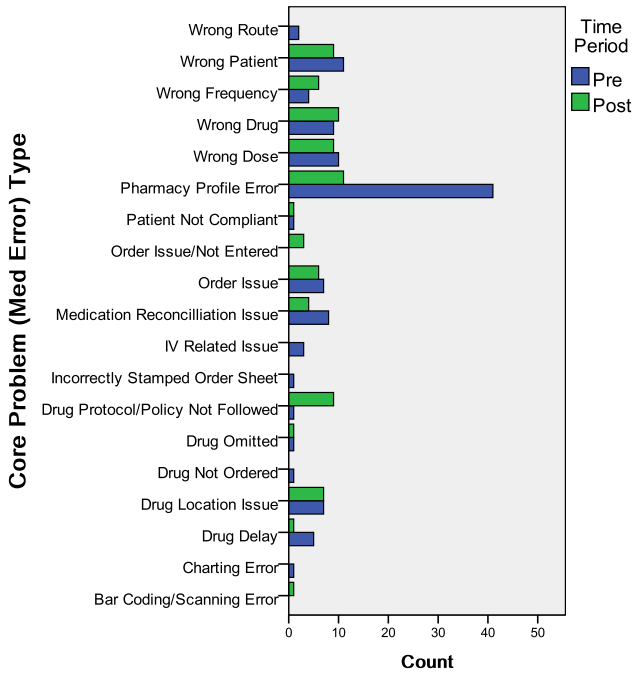



**Figure 42. Core Problem Type Counts by Period - MIMC.**

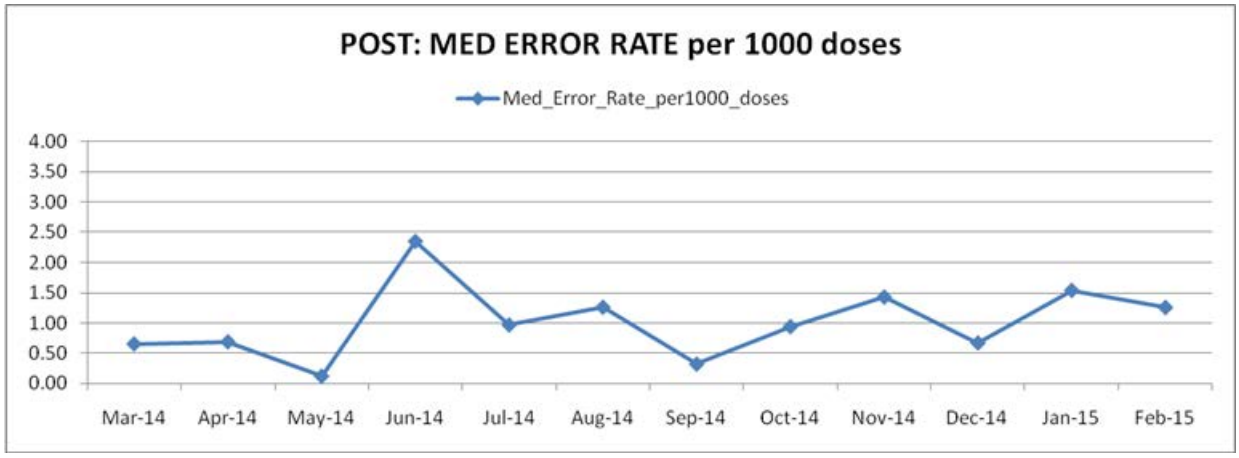



**Figure 43. MIMC Med error Rate per 1,000 doses - PRE.**

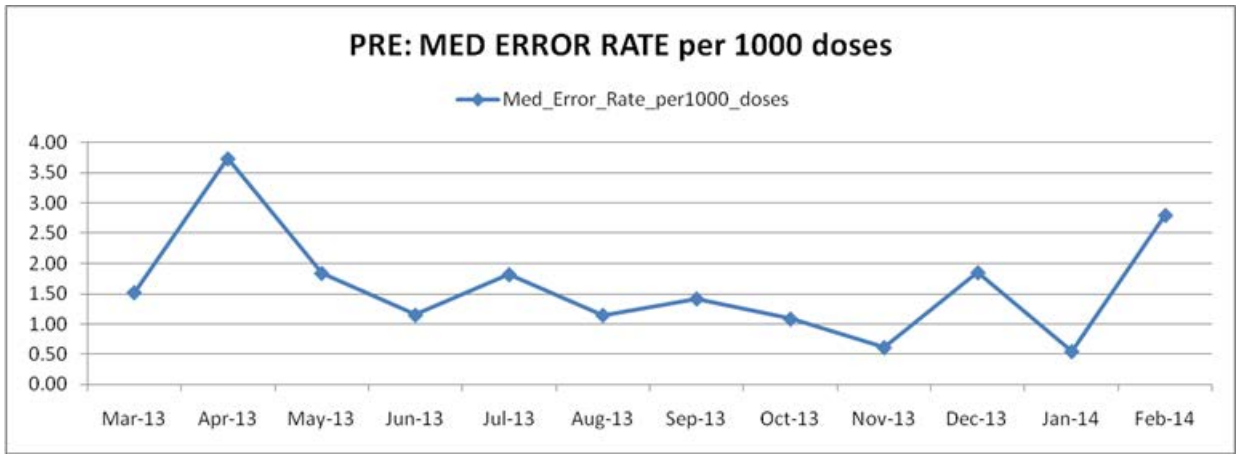



**Figure 44. MIMC Med Error Rate per 1,000 doses - POST.**

## General Discussion – Medication Errors

The medication administration process is not simply the act of administering medication, but rather complex processes involving multiple steps from numerous disciplines, departments, and users. Errors can appear at one, some or even all stages between the medication order process (prescription) through the actual administration of the medication and/or possible adverse events. Though a specific error may occur prior to a patient receiving the medication, most errors are noted only once the medication is incorrectly administered at the bedside.

Despite the fact that BCMA strives to assure the “five rights” of medication administration – right patient, right route, right drug, right dose, and right time, most studies however have investigated the effect of BCMA on the rate of severity of the errors or the effect of the BCMA on the duration of administering medication.

Medication errors can vary depending on the differing levels of care per clinical unit. A recent literature review study (Hassink J 2012) reports average baseline error frequency rates from 5.8-25.3% (1.6-27.8% if error times were excluded). Wrong time errors are generally considered to be less severe. Typical reports after BCMA implementation include a 30-50% reduction in medication errors, but only when time errors are excluded.

The severity of drug errors should also be included in discussion. Some studies have reported a nearly 50% reduction in risks post BCMA implementation (K. C. Poon EG 2010) (Franklin BD 2007) (Morris FH 2009). Error disposition (i.e. near miss or actual miss) per time periods, nursing unit, and other appropriate delineations may lead to subsequent conclusions about BCMA implementation. Initial discussions were rooted in the possibility that reporting frequency of actual vs. near miss may differ (e.g. near miss may be reported less frequently to save time; or near miss errors may be reported more POST BCMA implementation because nurses were disgruntled/dissatisfied with the technology and/or disruptions to their traditional workflow, PRE implementation).

Most medication error research however has been completed in small units and thus for comparative purposes that final data analyses may examine the impact of BCMA on specifically identified nursing units at Conemaugh. Differences between nursing units must be considered because of nurse-to-patient ratio, as well as hospital census differentials.

Work-arounds performed by nursing staff must be acknowledged as a contributing factor on the medication error rates. Table 35 demonstrates manual override statistics from MMC for July through September 2013. Though these reporting statistics were not available during the study time period, researchers utilized the data to make inferences to the impact on medication errors by clinical unit.

Considerations for future research are to see if medication errors could be segregated based on origination (i.e if drug dispensed from the robot vs the MedCarousel vs. manual picks results in any differences in the number, type etc. of medication errors). No past studies investigated user compliance in the BCMA system (ie. work-arounds with the BCMA system). Such may need to be re-evaluated over time since as system familiarity evolves, so could the work-arounds. Longer-term follow-up studies (> 2 years) are needed both for the aforementioned reason and also for examination of the degree and time post implementation.

### 1.2.12 Press Ganey™ surveys – MMC (Patient satisfaction)

Press Ganey™ surveys distributed as part of standard hospital operations were assessed to evaluate patient satisfaction in regards to BCMA. Data collection time periods ran successively from November 2010 - January 2012 (PRE) and from November 2011 – January 2013 (POST). Over 4,000 surveys were reviewed by members of the research team. Forty-nine medication related comments were retrieved during the PRE period and 63 during the POST data collections phase (Table 36). All medication-related comments and associated groupings were reviewed by the BCMA Clinical Team Leader and the Patient Representative from Patient Relations at MMC. Neither had recommendations or comments; accepting the data as presented. It is important to note, however, that many pain medications (controlled substances) are dispensed from Pyxis machines and are not a part of the pharmacy automation processes. MIMC and MYMC used different survey instruments.

| Comment Type | PRE Count | POST Count |
|---|---|---|
| | | |
| ***Delay*** | ***13*** | ***25*** |
| Medication administration issue | 8 | 8 |
| Did not receive medication | 8 | 9 |
| ***Adverse reaction/allergy*** | ***8*** | ***10*** |
| ***Medication order/rec issues*** | ***5*** | ***8*** |
| Lack of info about med provided to pt | 3 | N/A |
| Other | 2 | 1 |
| Positive med comments | 2 | N/A |
| Positive BCMA opinion | N/A | 1 |
| IT issue | N/A | **1** |
| TOTAL surveys | **1,989** | **2,066** |

**Table 36. Press Ganey Comments - PRE & POST.**

A statistical analysis comparing the percentage of comment type over time period was performed for the following comment types (Table 37). A p-value < .05 implies that the change in percentage is statistically significant. Significance was found for comments related to medication delays. Caution must be applied given that the percentages being tested are extremely small relative to the sample size (total surveys) and the expected 1-tailed p-value is significant, yet the 2-tailed p-value is not significant.

| Comment Type | p-value | |
|---|---|---|
| | *1-tail* | *2-tail* |
| Delay | **0.0330** | 0.0659 |
| Adverse reaction/allergy | 0.3475 | 0.6951 |
| Medication order/ rec issues | 0.2221 | 0.4443 |

**Table 37. p-values for Press Ganey Patient Comments – PRE & POST.**

### 1.2.13 CHS Physician BCMA/eMAR Survey (Physician Satisfaction)

Forty-two (42) clinicians, physicians, residents, hospitalists, or physician assistants (PAs) completed the Physician Survey (Appendix G). Responses were collected from May 2012 through March 2013, POST BCMA implementation. A copy of the survey is included as an attachment.

Two separate survey announcements via mass mailing were made, the second in November 2012, given the small response (n=9) of the first survey initiative, conducted in May of the same year. Of those survey respondents, 59% were physicians, 27% residents, 2% hospitalists, and 12% PAs. The respondents indicated a diversity of years of experience, with 44% indicating five or less, 22% twenty or more, and the remaining 34% from 6-20 years. 73% did not have BCMA or eMAR experience outside of Conemaugh. The majority of those surveyed responded favorably. Summary points from the survey are provided below.

- 90% of respondents indicated that they accessed the eMAR module through CarePortal

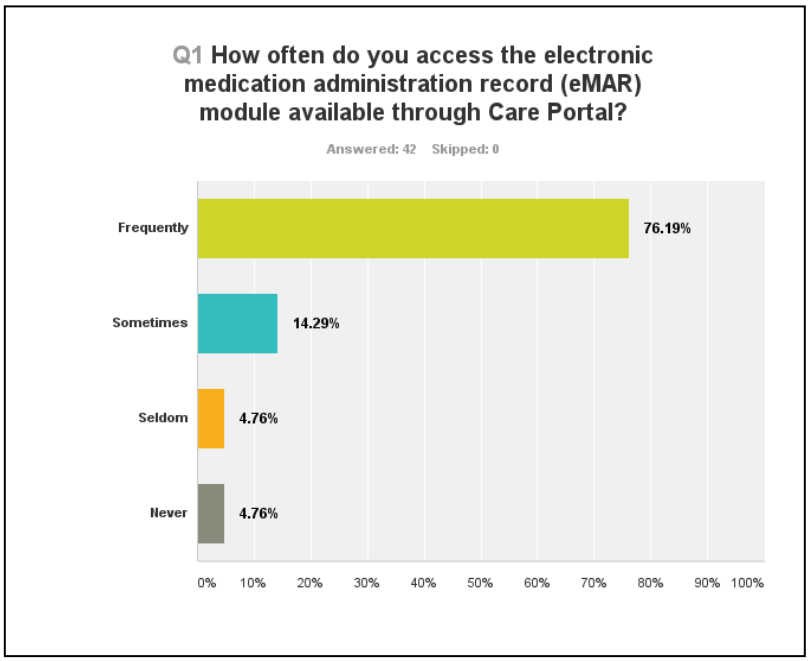



**Figure 45. Frequency of Access to eMAR module.**

- 67% either agreed/strongly agreed that the eMAR module has improved decision-making and efficiency

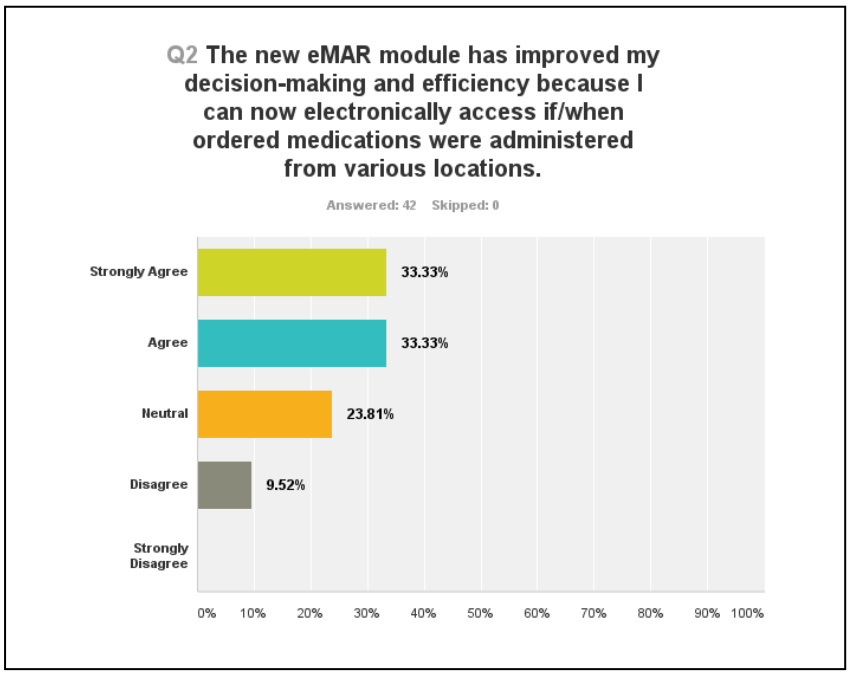



**Figure 46. eMAR Has Improved Decision-Making.**

- 43% believed that adverse drug events were reduced due to BCMA

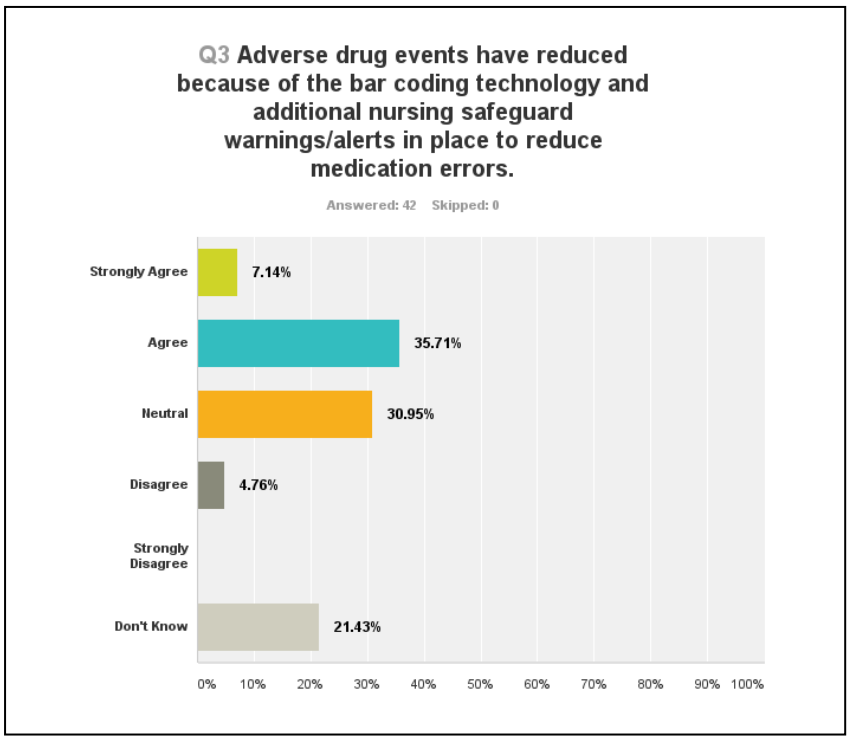



**Figure 47. Reduction in Adverse Drug Events.**

- 24% believed that BCMA improved physician communication with pharmacy and nursing (60% were unsure)

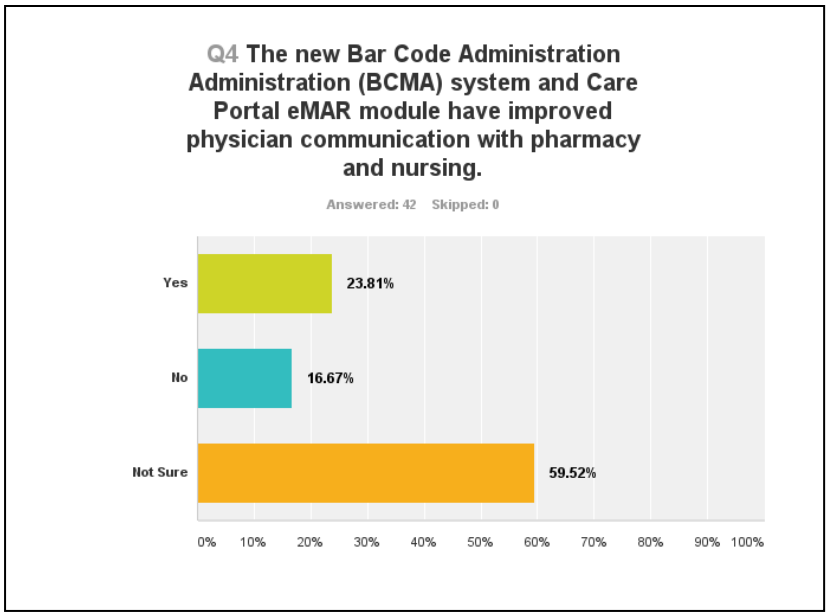



**Figure 48. Improved Communication Between Pharmacy and Nursing.**

- 48% would recommend BCMA and the accompanying CarePortal eMAR module

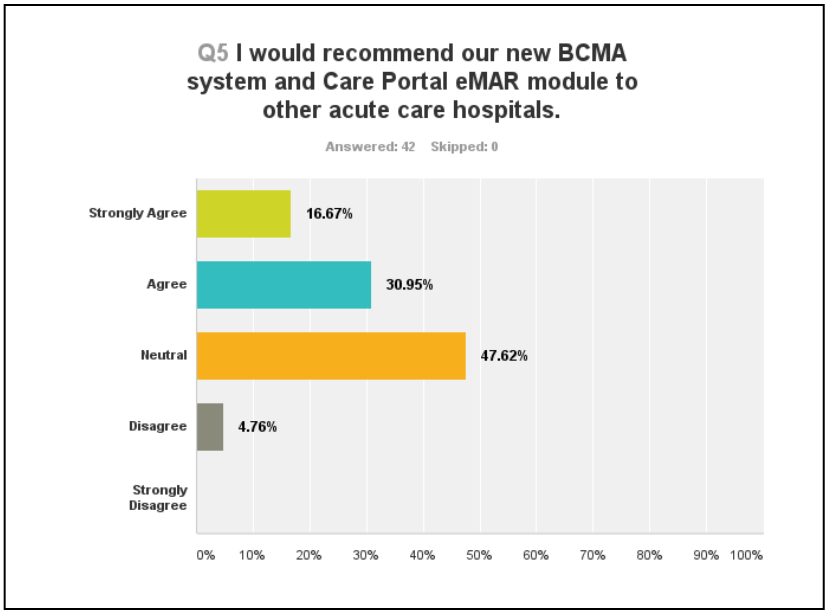



**Figure 49. Recommend to Other Hospitals.**

Additional statistical analyses, chi-square crosstabs by previous BCMA experience and years of service and non-parametric correlation, were attempted. These analyses were not tenable due to violations of required underlying assumptions.

Survey results by physicians indicated the BCMA system was not only favorably reviewed (nearing 50% positivity across categories), but also impacted efficiencies and reduced adverse drug events.

### 2.1.14 Late Medication Administrations (Re-budget Item)

The percentage of late medication administrations is reported as a way to measure the impact of the patient ID band printers deployed at the nursing stations. Data is available from HBI starting January 2013. Therefore it is challenging to conduct a Pre vs. Post comparison. For the 27 months reported, the percentage of "late admins" was variable and saw a slight increase of 1% over time. Late is defined as greater than one hour past the ordered administration time.

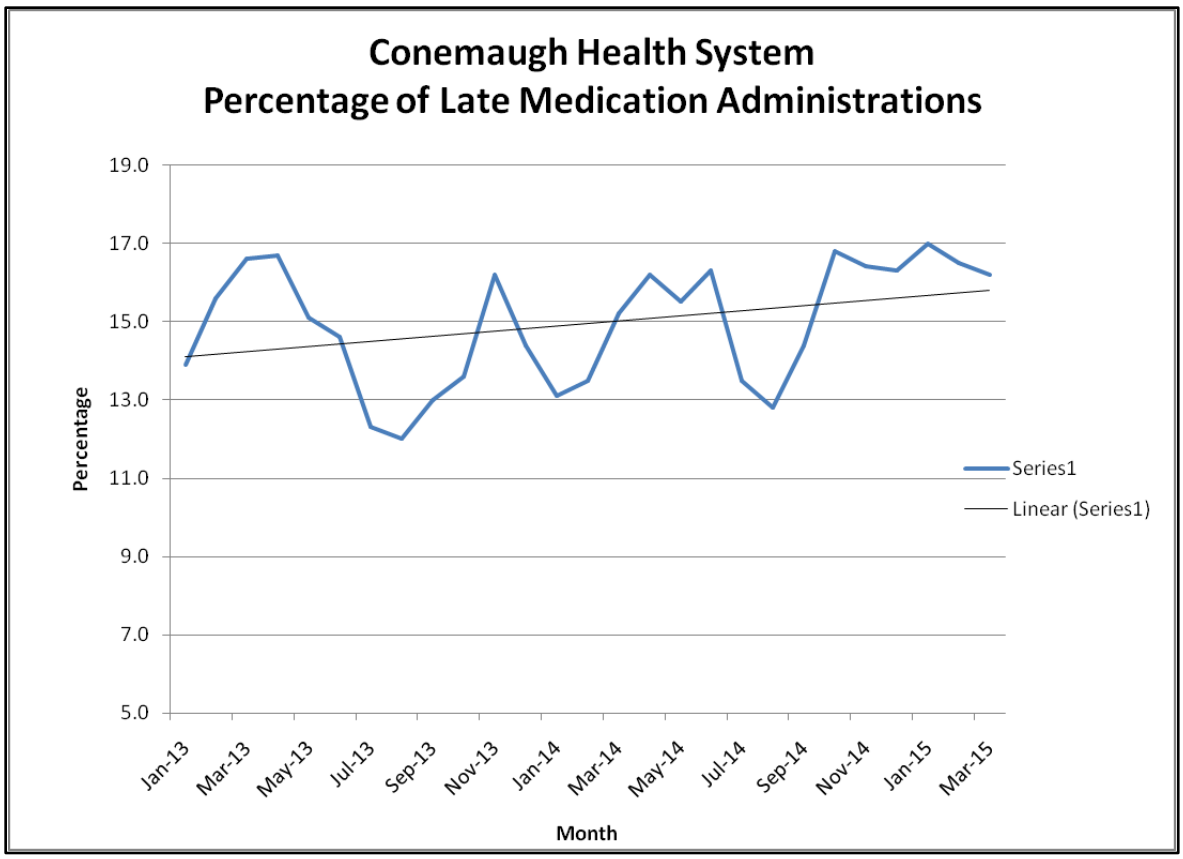



**Figure 50. Percentage of Late Medications.**

### Lessons Learned

Equipment issues were particularly troublesome and created challenges for the Pharmacy staff. These issues included the filling speed and location of stat orders, repackager inconsistencies and applicability to certain medications, suction issues with the robotic arm that resulted in dropped (missing) medications, and increased noise levels. One area of continued concern was the envelope delivery system, or EDS. The EDS will sporadically mis-function and cause some medications to miss the envelope. The vendor has improved the process via equipment adjustments, but reliability issues remained.

Unanticipated workflow issues for Nursing came to light as the new process was rolled out. One in particular was the continuation of previous habits. The previous decentralized medication distribution model required nursing to pull all patient medications from automated dispensing cabinets (ADC's) located on each nurse station. During the project planning phase, Pharmacy decided to leave the medications in the ADC's as a precaution in the event the new centralized distribution process had problems. Pharmacy discovered that Nursing was continuing to pull all their medications from the ADC instead of from the envelopes. The correct process is to pull only narcotics from the ADC, since all other medications are to be in the envelope. This resulted in envelopes being returned to the pharmacy full of medications and requiring manual crediting to the patient's account. The issue was exacerbated by the fact that the bar code medication administration (BCMA) process was not yet deployed and nursing did not have the new carts in place to house the medications sent from the pharmacy. Pharmacy addressed

the issue by providing additional education to Nursing and by removing the scheduled meds from the ADC's so that nursing must use the envelopes. Anecdotal concerns exist from nursing as they need to empty envelopes before placing specific medications into drawers on the mobile medication carts.

A second workflow issue involved hours of Pharmacy operation. Under the decentralized model, night-shift was a slow time with minimal activity other than off-hours order processing. This changed in the new Robot-driven centralized workflow model. Pharmacy learned that they need to utilize the midnight shift to perform cart fill so that the envelopes for the next day can be delivered to Nursing in the early morning. This change required a review of staffing so that additional staff is scheduled for the midnight shift.

A final operational issue involves the capacity of the automation system. We have learned that, even with optimization efforts, the combined capacity of the Robot and MedCarousel are not sufficient to meet the needs of Conemaugh's operations. Conemaugh contracted with McKesson for a second MedCarousel dispensing system to be installed in the Pharmacy.

Implementation of the Horizon Admin Rx BCMA system has provided many valuable lessons to the organization that can be shared with other stakeholders. The implementation has resulted in a positive safety improvement at all three hospital facilities, especially identifying near-misses before an actual error occurs. If the BCMA process is followed correctly by Nursing, it is highly likely the 5 rights of medication administration will be executed successfully. Nursing likes the electronic medication administration record (eMAR), especially where they can view past administrations. Many nurses do not like paper now and some of the younger nurses don't even know the "old way." In addition, physicians also have access to the eMAR via Care Portal and they do use this functionality when taking care of patients. Transitioning the medication administration record from paper to electronic has been very beneficial for patient care and safety.

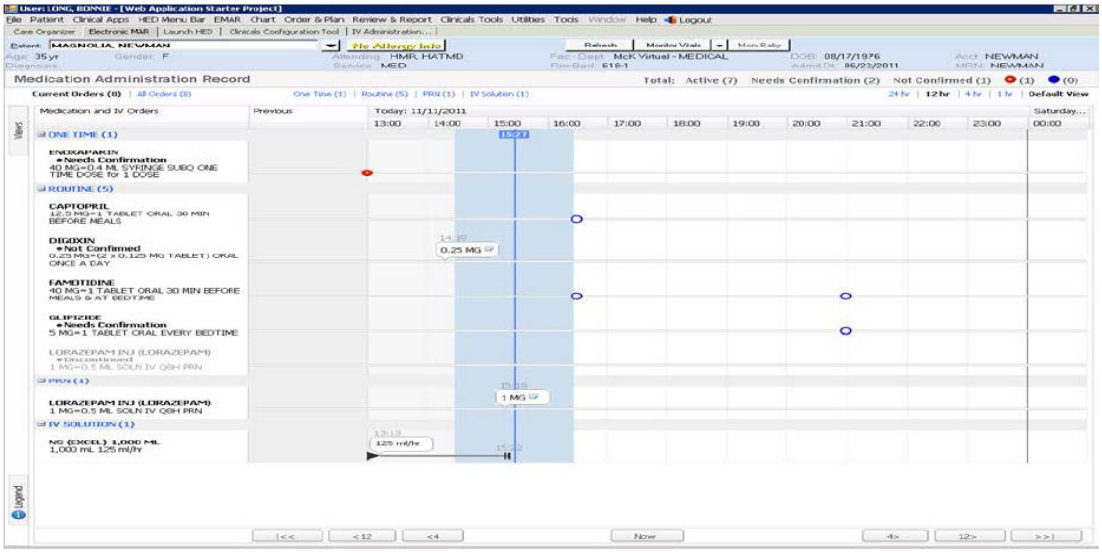



**Figure 51. Admin RX eMAR Module Screenshot.**

Bar codes not scanning successfully have been a chronic problem for the organization. Multiple barcodes on a single medication (e.g. on the medication and the package) have resulted in the nurse scanning the wrong one. Multiple manufacturers of the same medication have also caused problems. During the initial build of the table, some bar codes were missed by the IT department and therefore subsequent scanning did not work. The Duke Lifepoint acquisition also resulted in a major change in the

vendors supplying medications to the hospital. Also, large-volume IV's now come from the Warehouse and these barcodes are sometimes missed in the table. Communication has improved between Nursing and Pharmacy as a result of the most recent system upgrade which included a messaging function. The IV module is also improved in this version, which was a prior complaint from Nursing. For Intermittent therapies, you have a dilutant plus a medication. Pharmacy buts both items in bag and creates one barcode for both of these items, the end-user is NOT to scan the individual items but the barcode on the baggies. MYMC was scanning each item separately and getting a "no barcode found error" so they stopped scanning.

Another important lesson learned is to have early buy-in from Nursing and more stakeholders involved in the training and policy making phase. As we look back, we cannot stress enough how important this is in creating a successful culture of change within the organization. CHS still needs to strengthen its culture of safety through improved staff engagement, ideally led by the Chief Medical Officer (CMO).

Conemaugh purchased analytical tools for the Admin Rx software that provides very detailed information (by user, unit, drug, etc.) about the bar code medication administration process. All nurse managers were provided with direct access to these reports via a centralized electronic system. Unfortunately only three (3) nurse managers have accessed the system as of March 2015. This result is similar when talking about "Meaningful Use" scorecards as well. Some issues have included education/awareness regarding the reports and permissions (security). Nurse Managers have a lot of competing priorities and their use of this information is similar to other automated tools.

**Arm 2. Health Information Exchange (HIE) via the Nationwide Health Information Network (NHIN)**

**Subtask 2.1** Deploy a limited production, NwHIN standards-based HIE focusing on the bi-directional exchange of electronic medical records between CHS and the Military Health System. CHS information to include data domains residing in acute care and ambulatory settings.

**Subtask 2.2** Provide technical and documentation assistance on DoD-managed Virtual Lifetime Electronic Record (VLER) efforts.

**Subtask 2.3** Investigate productizing a Patient Consent module using established standards, such as TP20/XACML.

**Subtask 2.4** Assess and analyze NwHIN-related activities, to include data center performance metrics, physician evaluation and usage of the NHIN Portal, and resulting benefits of HIE with federal participants.

Project progression is briefly outlined below (Figure 52).

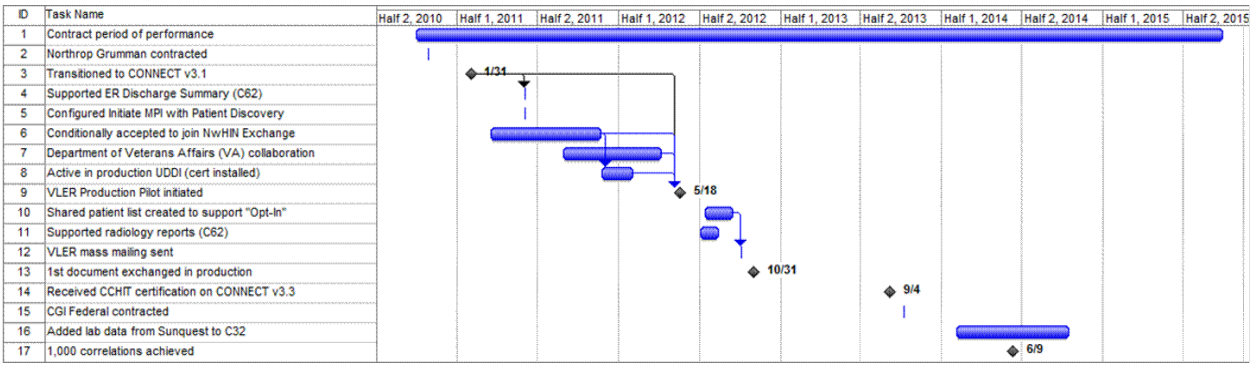



**Figure 52. MIDHT Project Timeline.**

Conemaugh successfully completed all four objectives (subtasks) with support from partners that included the: Telemedicine and Advanced Technology Research Center (TATRC), Department of Veterans Affairs, Northrop Grumman Corporation (NCG) and CGI Federal, Inc. Software development activities are listed in Appendix H. All objectives were fulfilled within budget during the period of performance.

When MIDHT first explored the use of HIE services, exchange was conducted through utilization of Nationwide Health Information Network exchange (NwHIN), formally a group of stakeholders and integrated delivery networks collaborating to securely exchange health information electronically. The NwHIN exchange at this point was a departmental programmatic operation of the Office of the National Coordinator for Health Information Technology (ONC). On October 12, 2012, the ONC transitioned to a public-private partnership to better foster continued growth and a sustainable business model, with the NwHIN now being identified as “eHealth Exchange” (http://www.hitechanswers.net/nwhin-exchange-

completes-transition-to-ehealth-exchange/). The eHealth Exchange (http://sequoiaproject.org/ehealth-exchange/about/history/) is made up of over 100 federal agencies and private partners that have implemented national standards and services for data sharing and all parties execute the Data Use and Reciprocal Support Agreement (DURSA), a common legal agreement, in order to securely exchange electronic health information (Figure 53). Participating organizations in eHealth Exchange mutually agree to support these common set of standards and specifications during the onboarding process.

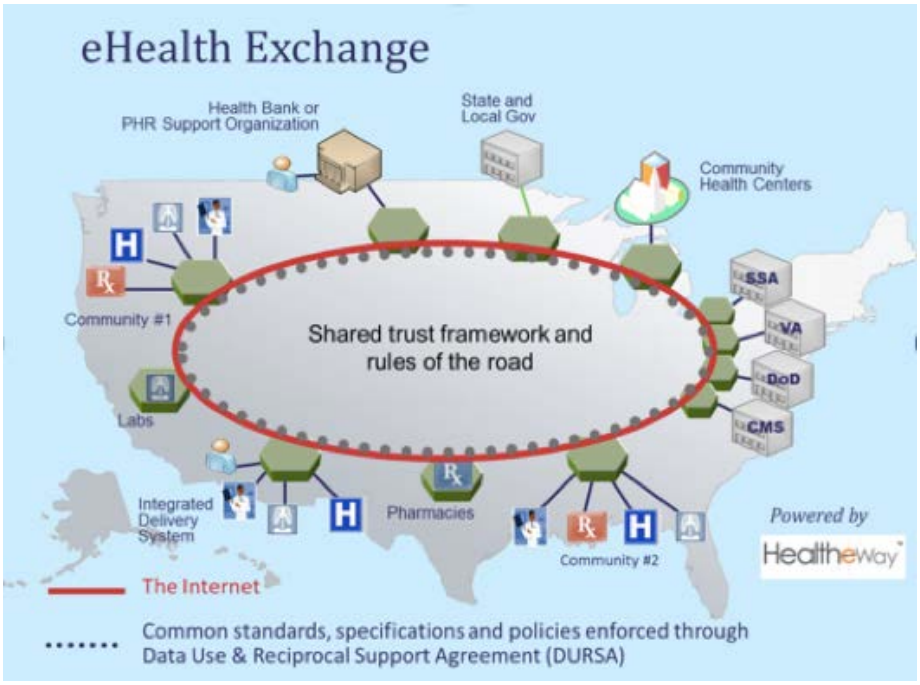



**Figure 53. eHealth Exchange.**

Conemaugh was proud to be the first Pennsylvania non-governmental health care organization and 23rd participant on the eHealth Exchange. Production data exchange occurred with the Department of Veterans Affairs. Work allotted Conemaugh to be recognized as the 13th VLER pilot site in the nation. Conemaugh first supported the Department of Defense during the Virtual Lifetime Electronic Record (VLER) Phase 1a pilot.

The core of MIDHT built upon the successful participation in the VLER pilot and provided a platform in which U.S. veterans in rural Pennsylvania could have components of their medical record seamlessly exchanged electronically between Conemaugh and the James E. Van Zandt VA Medical Center (Altoona, PA). At the conclusion of the MIDHT program, Conemaugh established a three year production exchange of live patient data via the eHealth Exchange, including:

- data domains from three electronic health record systems; Allscripts (outpatient), McKesson (inpatient) and Sunquest (laboratory)
- CCHIT certification
- relevant code contributions to the open-source CONNECT community
- an ONC supported pilot for electronic patient consent

Conemaugh continually applied revisions to our health information exchange architecture to stay current and meet partner needs. Brief level summarizations are included within this report.

In addition to the technical infrastructure necessary for establishment of the proposed health information exchange (Subtasks 2.1-2.3), MIDHIT additionally assessed and analyzed NwHIN-related activities (Subtask 2.4). Within that scope, the following research objectives were investigated.

Both of the following hypotheses have been accepted:

1. The use of the health information exchange (HIE) via the NwHIN – CONNECT architecture will be different between the Conemaugh Health System and the Department of Veterans Affairs.

2. Conemaugh satisfaction with HIE via the NwHIN – CONNECT architecture will be greater than that for the existing (mostly paper-based) process of exchanging health information between the Conemaugh Health System and the Department of Veterans Affairs.

*** However this hypothesis is accepted with caution due to small sample size (n=14)*

# Research Objectives

1. Assess and analyze production data center performance using common industry metrics
2. Quantify the number of Conemaugh patients opted-in and successfully correlated with VA (i.e. relative to total count of eligible [common] patients)
3. Quantify provider usage of the NwHIN Exchange
4. Evaluate patient satisfaction of the NwHIN Exchange
5. Evaluate provider satisfaction of the NwHIN Exchange and CONNECT UniversalClientGUI

# Project Activities, Outcomes and Conclusions

### *The MIDHT eHealth exchange "Gateway" - System Overview*

As per The Sequoia Project website (http://sequoiaproject.org/ehealth-exchange/), the eHealth Exchange ("Exchange") is a group of federal agencies and non-federal organizations that came together under a common mission and purpose to improve patient care, streamline disability benefit claims, and improve public health reporting through secure, trusted, and interoperable health information exchange." In support of the eHealth Exchange mission, the MIDHT program established a "Gateway" that served as an onramp to the eHealth Exchange network.

The main component of the Conemaugh "Gateway" is the CONNECT open-source software, which supports the following sub components:

- Core Services – Facilitates secure messaging services, including Patient Discovery (PD), Query for Documents (QD), and Retrieve Documents (RD)

- Enterprise Services – Also known as the "Adapter" level, these services bridge the Core Services to the existing Conemaugh infrastructure

- Universal Client Framework – Provides user-facing Graphical User Interfaces (GUI) that are used to conduct PD, QD, and RD queries and set/change the consent directive for a given patient.

The CONNECT open-source software, working in conjunction with an open-source registry/repository, an open-source access control platform ("OpenSSO), an open-source directory service ("OpenDS"), a consumer-off-the-shelf (COTS) Enterprise Master Patient Index (EMPI), and COTS EHRs, enabled Conemaugh to share structured Continuity of Care Documents (CCD) and unstructured C62 documents with other eHealth Exchange participants.

Figure 54 depicts Conemaugh's eHealth exchange architecture.

A "Technical Services Agreement" was fully executed between subcontractor Northrop Grumman Corporation (NG) and CHS on October 26, 2010. NG had staff from three states (Pennsylvania, Utah and Virginia) supporting the contract through October 2013. CGI Federal, Inc. was awarded a subcontract on October 7, 2013 through the remainder of the MIDHT period of performance (POP) after a competitive selection process after the NG contract was terminated. Noteworthy software development deliverables are located in

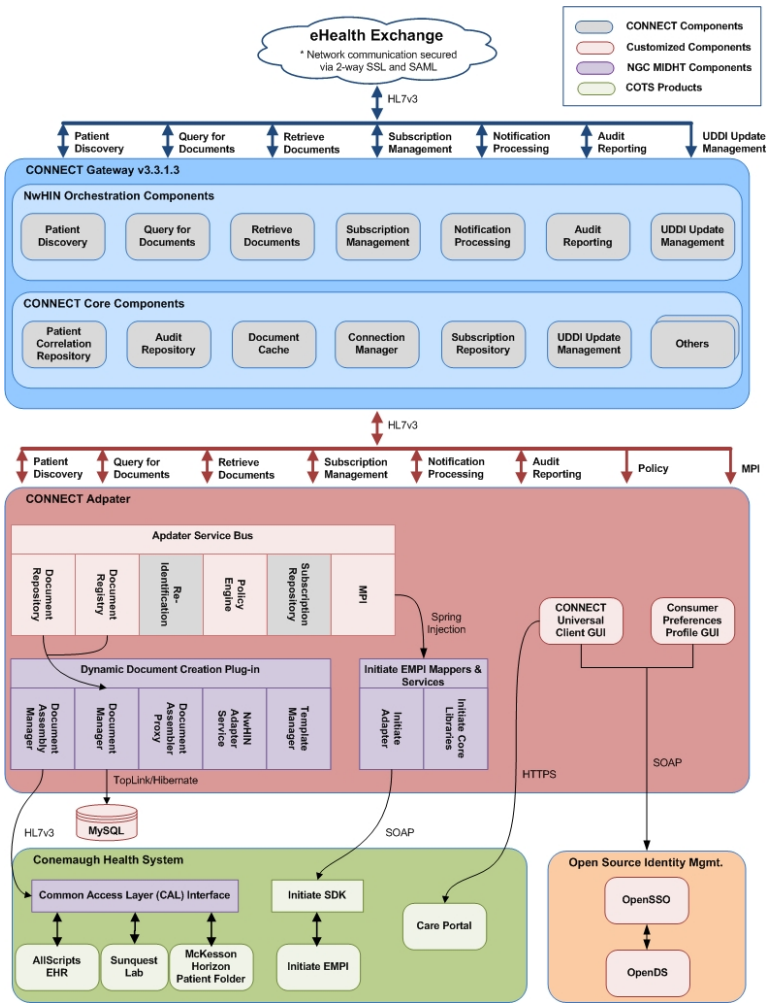



**Figure 54. Conemaugh's eHealth Exchange Architecture.**

***Subtask 2.1 Deploy a limited production, NHIN standards-based HIE focusing on the bi- directional exchange of electronic medical records between CHS and the Military Health System. CHS information to include data domains residing in acute care and ambulatory settings.***

Conemaugh and subcontractors have worked closely to design and implement a standards-based health information exchange using the five core NwHIN specifications, which include patient discovery, document query, document retrieve, messaging and authorization.

**NwHIN Onboarding Review**

In order to participate in the NwHIN, participants must complete various phases of the Onboarding process before exchanging data. Test data was entered by MIS staff on various patients, including demographics (Initiate MPI) and clinical documents (Allscripts). Technical issues encountered during various testing sessions with ONC contractors were subsequently resolved during each phase allowing for conformance and interoperabilitytesting. Conemaugh was conditionally accepted to participate in the "Exchange" on November 20, 2011 (Appendix I).

Monthly NwHIN coordinating committee meetings were attended throughout the process. The various phases of the Onboarding process are outlined in Table 38. All onboarding activities were successfully completed on January 27, 2012. Activities included operationalizing the Go-LIVE endpoints by addition to the production UDDI and installing the production ONC certificate in the MIDHT server.

| Onboarding stages | |
|---|---|
| **Stage 1: Qualification** | ✓ After self-qualification, organization submits completed application package including the signed Data Use and Reciprocal Support Agreement (DURSA)<br>✓ NwHIN Implementation Team reviews application package and works with the organization as needed to complete the package<br>✓ NwHIN Implementation Team reviews application package and coordinates an eligibility review with the NwHIN Coordinating Committee (NCC)<br>✓ NCC reviews application package to ensure organization meets all eligibility requirements |
| **Stage 2: Validation** | ✓NwHIN Implementation Team sends test certificate and validation framework information to organization<br>✓Organization configures its test environment and executes conformance and interoperability testing<br>✓Organization submits evidence of successful tests to NwHIN Implementation Team<br>✓NwHIN Implementation Team prepares validation package and submits to NCC |

| | |
|---|---|
| **Stage 3: NCC Review** | ✓NwHIN Implementation Team coordinates a review with NCC to evaluate the application and validation results<br>✓NCC evaluates application and makes a decision on whether to conditionally approve the organization or disapprove the organization and request remediation (if applicable)<br>✓NCC notifies the NwHIN Implementation Team and the organization of membership status |
| **Stage 4: Activation** | ✓NwHIN Implementation Team provides production certificate and requests production registry information from the organization<br>✓Organization provides production registry information to NwHIN Implementation Team<br>✓NwHIN Implementation Team configures NHIN registry with organization's information<br>✓NCC executes the DURSA Joinder<br>✓NCC notifies organization of NHIN membership<br>✓Organization is now a NwHIN Participant and ready to exchange data over the NwHIN Exchange |

**Table 38. Onboarding Stages.**

Prior to deployment, the HIE environment was updated and integrated with open-source version CONNECT 3.1. Two web services required updates to match the WSDLs in CONNECT v3.1. Other integration issues were resolved by: 1) eliminating "Dispatch" errors through the condensation of endpoints in the Document Manager web service, and 2) redirecting the hibernate code to local configuration files. Other work included: patient discovery with Initiate Master Patient Index, restructuring of xml consistent with HITSP C32 specification, integration of emergency room discharge summaries in HITSP C62 format and, completing the NWHIN conformance/interoperability testing with the ONC. Please refer to Appendix J and Appendix K for C32 and C62 examples respectively.

The following three components were critical to develop and test before individual health data could be exchanged (namely, Patient Discovery, Patient Consent, and Patient Matching).

## Patient Discovery

The Patient Discovery service was based off of the eHealth Exchange Patient Discovery specifications, which defines how patient matching occurs across the network. The Patient Discovery service provided a mechanism in which the MIDHT "Gateway" could query another eHealth Exchange participant to determine if the same patient existed at the participant's organization. Likewise, a remote eHealth Exchange participant's organization could query the MIDHT "Gateway" to see if a matching patient existed.

The Patient Discovery process was initiated when demographics (e.g. First Name, Last Name, Date of Birth [DOB], Gender, and Social Security Number [SSN]) associated with a patient were extracted from the requesting organization's EMPI, and then broadcasted to other Exchange participants. Only, and if only, a single matching patient was found at the responding organization, the responding organization returned a response containing a patient identifier and the patient's set of demographics. Upon receipt of the response, the requesting organization verified the demographics against their local EMPI to ensure that both agree on the patient's identity. If an agreement was reached between two organizations that a single patient match had been achieved, then the patient identifier from the requesting gateway was correlated with the patient identifier from the responding gateway and saved in a patient correlation repository. Clinical users were then able to view correlations for a given patient via the CONNECT Universal Client GUI web portal (Figure 55).

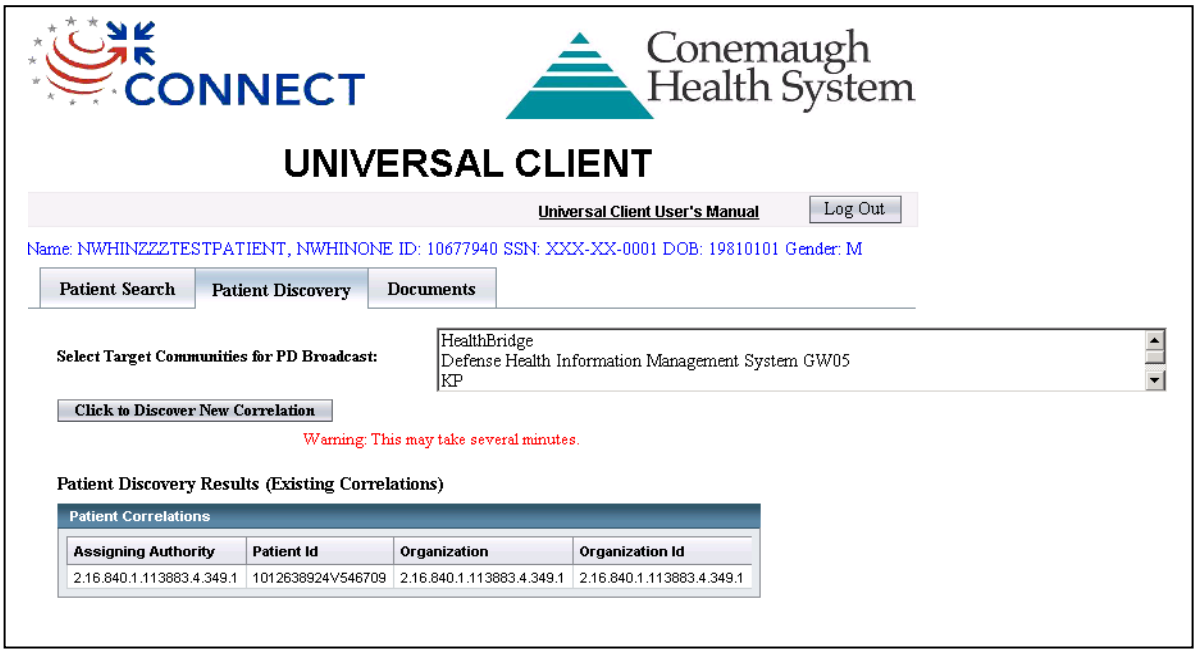



**Figure 55. Patient Correlations Displayed in CONNECT Universal Client GUI.**

In the case of the responding gateway returning multiple patient matches, the requestor received a response that contained a no match result – which was their original web service request contained within the response.

## Patient Consent

The MIDHT patient consent model was that of "opt-out" by default, where CHS was not authorized to share a patient's information until a signed paper consent document was obtained from the patient. Before patient information was shared between organizations, both CHS and VA had to receive consent from a patient to release his/her medical information. Once consent was obtained, the patient was "opted-in" by Conemaugh staff using the Consumer Preferences Profile (CPP) GUI (Figure 56).

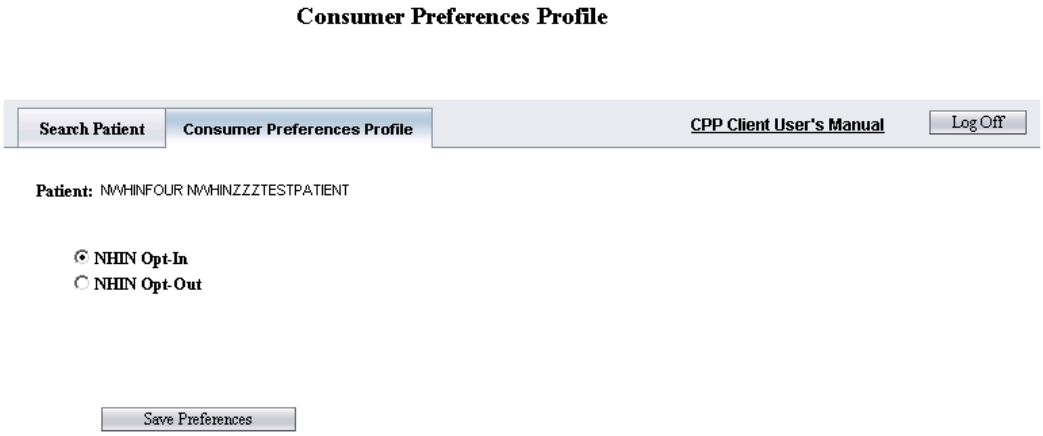



**Figure 56. CPP GUI**

## Patient Matching

Patient matching accuracy was of critical importance during the Patient Discovery process. For the MIDHT project, an identity resolution strategy that stressed probabilistic matching for verifying the identity of a patient was implemented to identify a single patient from mutable and immutable identifiers. To achieve the best possible match, a matching strategy that provided identity integrity addressed the following key areas that could impact the matching of records:

- Quality of Data – A good matching solution must utilize strong identifiers, must address variations in syntax, differences in semantics, and must account for missing and incomplete data values.
- Quality of Matching Criteria – The matching criteria associated with the deployed algorithm must be set high enough to diminish the presence of false positive results (information for multiple patients appear to be a match for a given set of demographics) as well as a small number of false negatives (multiple records for the same patient are returned), but not so high that no results are returned.
- Quality of the Matching Algorithm – The matching algorithm shall support the best matching accuracy.

Because the eHealth Exchange does not offer the benefit of a National Patient Identifier (NPI), unattended probabilistic matching solutions offer the best chance at finding a patient match. In the case of the MIDHT "Gateway", probabilistic matching was tuned using a min score criteria to meet customer defined matching requirements.

Since the Patient Discovery process was so heavily dependent on making matches via probabilistic matching algorithms, it was imperative that min score criteria be adjusted to account for missing or incomplete data. During implementation of the MIDHT "Gateway", the EMPI min score needed to be "dialed-in" to a setting that could best support patient demographics containing varying levels of information robustness and completeness. Inclusion of the patient's Social Security Number (SSN) was a great benefit to our correlation efforts. Not all VA partners included this demographic field.

## Query for Documents

The Query for Documents service enables an eHealth Exchange participant to request a list of clinical documents from other Exchange participants. However, the Query for Documents service is dependent on the Patient Discovery service, and requires a patient to be correlated between organizations before documents can be exchange between those organizations. The Query for Documents process begins when an eHealth Exchange participant sends a Patient Identifier (PID), obtained during Patient Discovery, to a remote participant to identify the patient for which they would like a list of documents. The remote organization then returns a list of documents pertaining to the requested patient.

As per the 2011 eHealth Exchange specifications, the documents in the returned list are classified as "Stable" or "On-Demand" documents. "Stable" documents are documents that contain metadata describing the document when it was created and made available for retrieval. On the other hand, On-Demand documents contain metadata describing a document that is to be created when the requestor attempts to retrieve it. When the MIDHT "Gateway" receives a Query for Documents request, a list of documents is returned to the requesting organization - but only after the document has been dynamically created from information that originates from CHS's Electronic Health Record (EHR) systems. Though, the MIDHT Query for Documents response is similar to what is described in the On-Demand specification, documents returned by the MIDHT "Gateway" are considered to be "Stable" documents because the document and its metadata are created during the Document Query process and made available for retrieval.

## Dynamic Document Generation

When a Query for Documents request is received by the Conemaugh gateway, a C32 and/or C62 clinical document is dynamically created using a Dynamic Document Generation plug-in for the CONNECT architecture, and the metadata about each created document is returned to the requestor. The Dynamic Document Generation architecture, which is comprised of a Document Assembly Web Services Interface, a Templates component, a Document Assembly component, a Document Repository component and a Common Data Layer Web Services Interface, is responsible for transforming raw data from Conemaugh's EHR systems into structured and unstructured clinical documents.

The process begins when CONNECT passes an incoming Document Query request to the Document Assembly Web Services Interface, alerting the Dynamic Document Generation architecture that a clinical document has been requested. The Document Assembly component then receives the request from the Document Assembly Web Service Interface and begins the process of building a Clinical Document Architecture (CDA) document. The CDA document construction process begins when the Document Assembly Manager component calls the Templates Manager to retrieve template information from a database table. The database table contains information regarding which modules and sections comprise a particular type of CDA document and which modules and sections have been enabled by the gateway administrator. The information retrieved from the templates database table is then used to make calls to the Common Data Layer Web Services Interface, which returns information from the EHR systems. The data is aggregated into a clinical document, which is saved in the document repository, along with its associated metadata, via the Document Repository component. The document information is then extracted from the repository and packed into a Document Query response, which is returned to the requestor.

One of the keys to responding to Document Query requests with dynamically created clinical documents is to ensure that the EHR systems, from which you extract the data, have mechanisms in place for exporting data. The ridged architecture of the Commercially Off-The-Shelf (COTS) EHRs at Conemaugh had to be augmented with a custom solution to ensure that the required clinical data could be extracted from the EHRs and packaged in a format suitable for transmission across the eHealth Exchange. Another key to dynamically creating CDA documents is ensuring that the mapping of data from the EHR systems to the CDA documents is accurate and complete. Often times, the format and/or content of the EHR data are not conducive to meeting the CDA specification. To address this issue, the MIDHT "Gateway" deploys a series of custom "mappers" that transform the content and structure of certain pieces of data as the CDA is being created.

### Document Retrieve

The Document Retrieve services provide a mechanism in which an eHealth Exchange participant is able to retrieve one or multiple clinical documents from a remote participant. The services are utilized after a unique document identifier is received in a successful Document Query response. This unique identifier is used in the Document Retrieve request to identify which document(s) should be returned to the requesting participant. When a Document Retrieve request is received by the MIDHT architecture, the Document Repository component is responsible for querying and retrieving the document(s) from the document repository.

One of the challenges of the retrieving clinical documents from a remote eHeatlh Exchange participant is making sure the documents are viewable when they are received. Since clinical information in a CDA document is represented as both summary information and information in the body of the CDA document, an organization must decide how they will parse and display the information. As Conemaugh learned when they first began exchanging data with the VA, one style sheet is not conducive to displaying information from disparate organizations. Instead of using the style sheet that Conemaugh had been using to view their structured data, a new style sheet had to be developed in order to view the content of clinical documents that are returned by the VA.

### 2.1.1 VLER Exchange Activities - Conemaugh and James E. Van Zandt VA Medical Center

The VLER program was discussed with various healthcare groups within Conemaugh and the VA. Meetings focused on various topics, including the eHealth Exchange, clinical data availability, system usage, and qualitative surveys. First sample documents from the VA were received in November 7, 2011. VA C62 class codes were received approximately one month later and added as an option in the doc query request to the VA. Testing began in January 2012 with the first production document transaction occurring in October 2012.

An initial 13 patients, who were "opted in" at the VA Johnstown Community Based Outpatient Clinic (a CBOC of the James E. Van Zandt VA Medical Center) and successfully correlated via patient discovery, served as the data set for validation testing (against production data). Additional meetings between stakeholders were then used to also discuss the availability of Conemaugh C32 data and other data quality issues.

On September 11, 2012 Conemaugh provided and extensive patient list to the VA that included 116,616 patients with C32 and C62 data available from the past two years. The VA performed a match against the

patient population at the James E Van James E. Van Zandt VA Medical Center - Altoona, PA, creating a "shared" patient list that was then used for a mass US postal mailing of consent forms. For patients who did not have a primary care physician on file, Allscripts EHR was used to uncover the information. Before distribution, the patient file was reviewed for deceased patients and address changes. Patient lists were then generated for each provider practice that was first piloting the program and shared for review.

In October 2012, over 355 veterans were mailed the joint patient information letter (Appendix L), two consent forms (Appendix M and Appendix N), and marketing materials (Appendix O) regarding the exchange. MIDHT staff 'opted-in' specific patients through the CONNECT CPP. The VA forms were provided on a weekly as needed basis. Patient correlations were then checked frequently to determine the attars of the linkage. Once a correlation was made between Conemaugh and the VA, MIDHT staff added chart alerts within the Allscripts electronic health record to notify providers (Figure 57).

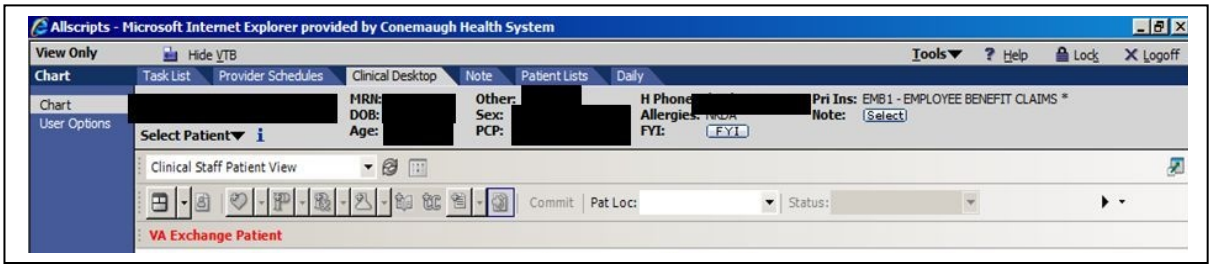



**Figure 57. Allscripts Chart Alert.**

A second patient list consisting of patients that had been referred from the VA to Conemaugh in the past two years (2012-2014) (approximately 300) also received program information. It was decided that the Altoona VAMC would manage this manage mailing moving forward. Discussions with the Department of Veterans Affairs (VA) regarding future patient mailings had been ongoing throughout the period of performance.

Conemaugh utilized internal marketing resources to promote the VA partnership and VLER project. Content was distributed via the following means: an employee newsletter, physician newsletter, individual provider office meeting, and press release (with advance review by TATRC) (Appendix P).

Working with administration, ambulatory users primary from family medicine were informed of the project and training then commenced. Individual system accounts were created to allow end users to request data.

From May 2012 through September 2015, 1,150 patients returned authorizations with 1,136 opting-in to the service (NwHIN exchange) and 1,135 correlations (Figure 58). The exciting milestone of 1,000 correlations was achieved on June 9, 2014. Of those correlated:

- 99.7% (1,103/1,136) were male
- For those opting in and successfully correlated, the average age was 71 years
- 99% (1,136/1,150) success rate for patient discovery messages

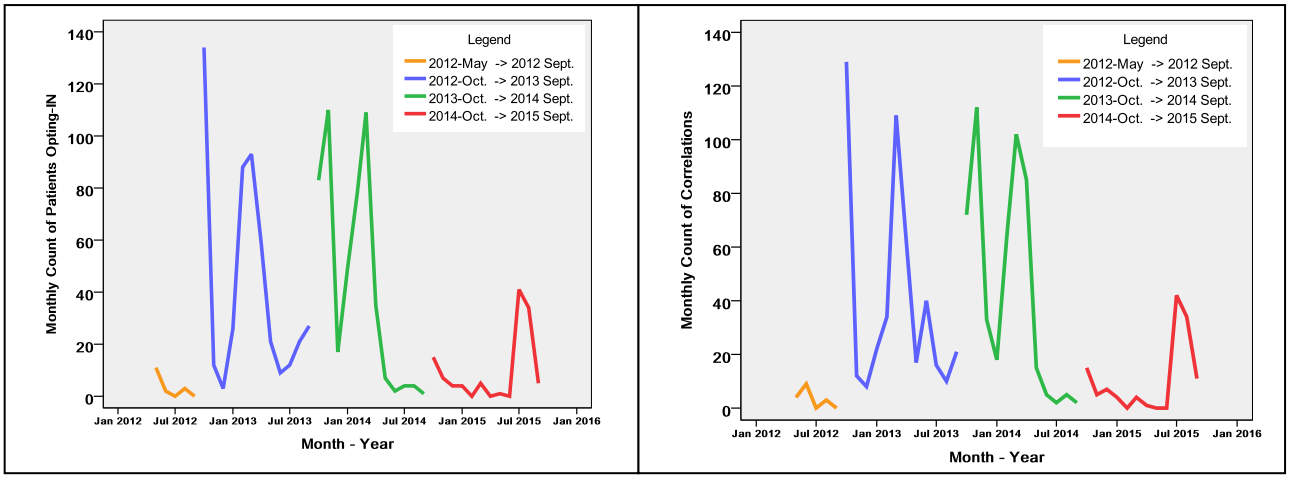



**Figure 58. eHealth Exchange Return Authorizations and Correlations**

The return rate of authorizations was directly correlated to the joint mass mailings spearheaded by Conemaugh. The difference in the number of veterans that responded and are correlated is not due to patient discovery failures but rather issues with VLER authorizations (e.g. not signed/dated, not completed) and the time delay for both organizations to "Opt-In" patients into their system. Again, specific patient information could not be exchanged through the eHealth Exchange until permission was granted from the Veteran.

The incorporation of lab results from the Sunquest lab system into the CONNECT environment was requested by VA users and was a major project milestone. Conemaugh first began work with Sunquest on the HL7 interface for laboratory results during February 2014. Live testing of the Sunquest interface with live data posed problematic, and as a result restrictions were placed on microbiology and blood bank results. John Hargreaves worked with the CONEMAUGH lab to provide documentation to meet the College of American Pathology (CAP) interface requirements.

The first successful lab query response was completed on March 13, 2014. A handful of issues including integration into the CONNECT environment and C32 document were resolved during the summer before. Testing with the VA was regarding the laboratory results were completed on August 18, 2014.

Throughout the POP, Conemaugh upgraded Allscripts software versions. MIDHT integration and functionality was changed as needed, tested and put back into production efficiently.

### 2.1.2 VLER Exchange Usage

Successful document retrieve transactions for treatment purposes through the eHealth Exchange increased over time but did vary (Figure 59). Figure 60 is an overall representation by document type with Figure 61 displaying exchanged documents by direction of receipt. Data is continuous on a monthly basis.

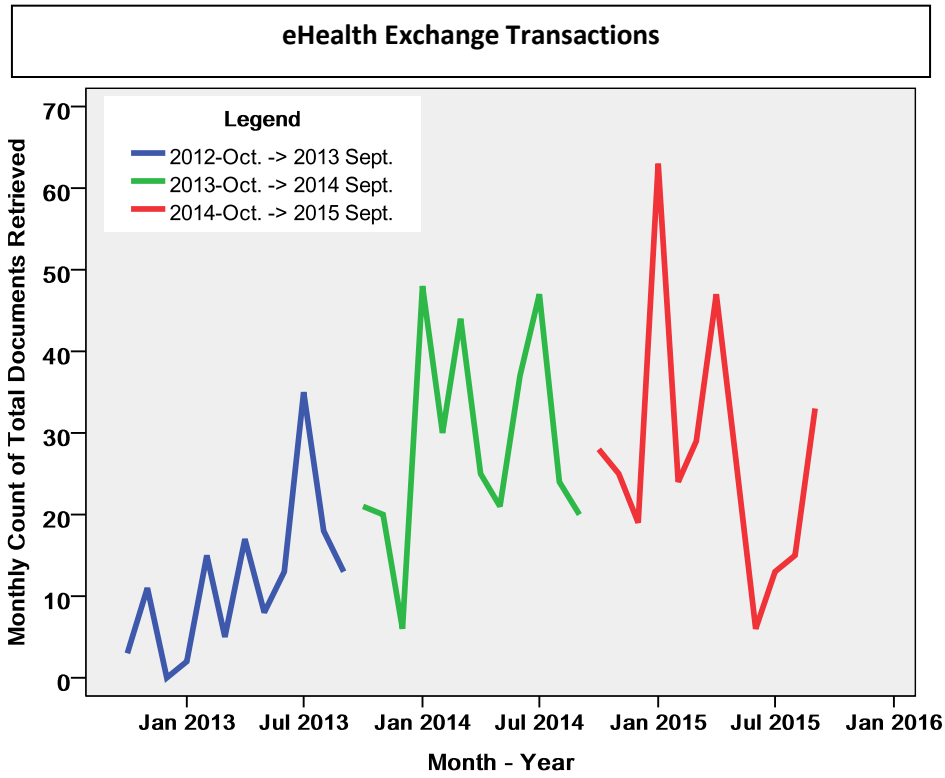
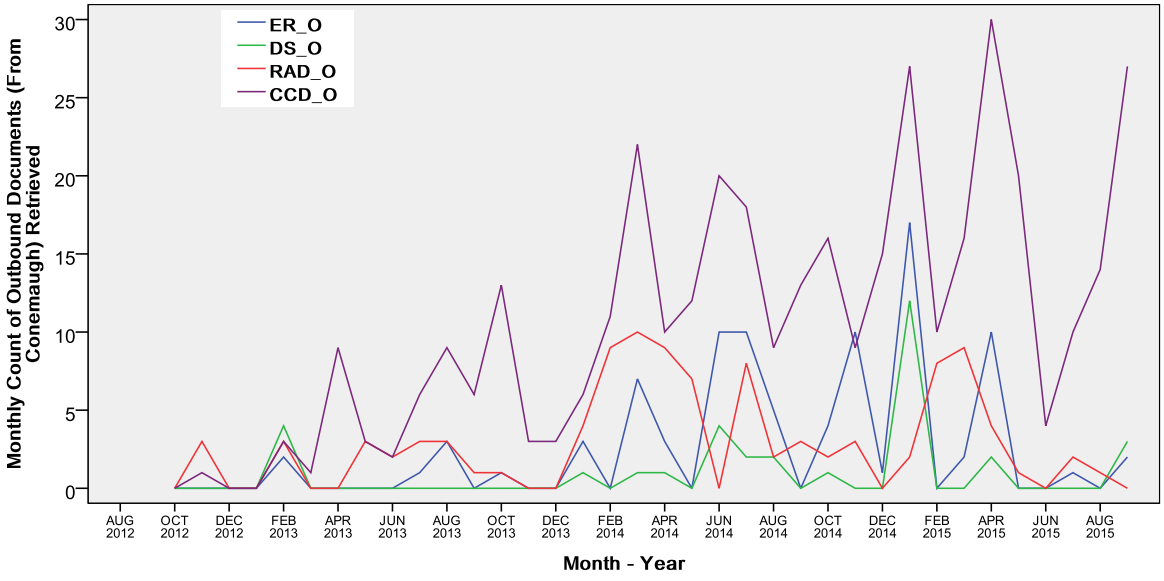
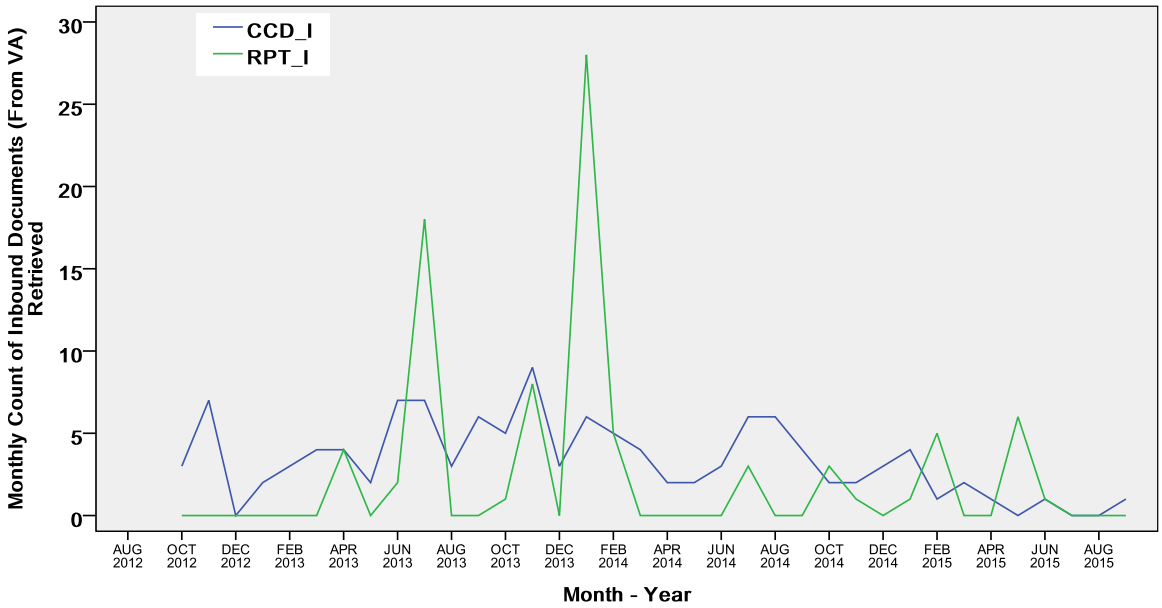



**Figure 59. eHealth Exchange Transactions during POP.**




| |
|---|
| CCD_O = Continuity of Care Document Outbound |
| RAD-O = Radiology Report Outbound |
| DS-O = Discharge Summary Outbound |
| ER_O = Emergency Room Note Outbound |

**Figure 60. eHealth Exchange Transactions by Document Type.**




| |
|---|
| CCD_I = Continuity of Care Document Inbound |
| RPT_I = C62 Reports Inbound |

**Figure 61. Inbound vs. Outbound. Continuity of Care Documents.**

Conemaugh providers prefer retrieving VA lab results and medication history via the continuity of care document (CCD). Retrieval of C62 reports from the VA was minimal and highly influenced by one user/day. Likewise, VA providers have preferred to retrieve the CCD from Conemaugh and also radiology reports. Retrieval of emergency room notes and discharge summaries have also been minimal. Interestingly, the initiation of document retrievals is nearly a 50/50 split.

Allscripts Clinical Analytics software was made available to Conemaugh in May 2014. The purchase agreement was executed with the vendor six months prior (November 1, 2013). Staff training was conducted via webinars and workshops. Clinical data on veterans was extracted according to 2014 American Diabetes Association (ADA) standards. Data was consolidated for presentation to system users. The MIDHT team worked closely with the CPG Director of Primary Care on review and distribution of the data to physician practices. The initial dataset was distributed on September 3, 2014, with intentions to increase document queries by Conemaugh users by analyzing existing clinical data in the electronic record and comparing it to national standards in order to identify gaps in care. Unfortunately document queries by Conemaugh for diabetic patients was less than five and did not produce a realizable value.

### 2.1.3 Direct Exchange Push vs. Query-Based Exchange Comparison

The following analysis compares the direct exchange push functionality purchased from McKesson currently in a limited production state and the query-based approached currently in production via the eHealth Exchange and Virtual Lifetime Electronic Record (VLER) program.

*Direct Exchange Push Inbound*

When a patient's clinical document architecture (CDA) is sent to our health system from an external source and attached to the patient record, the information is visible to CHS providers under the Transcription tab in Care Portal as an Exchange Message-Inbound CDA (Figure 62). See Appendix Q for specific inbound documentation instructions.

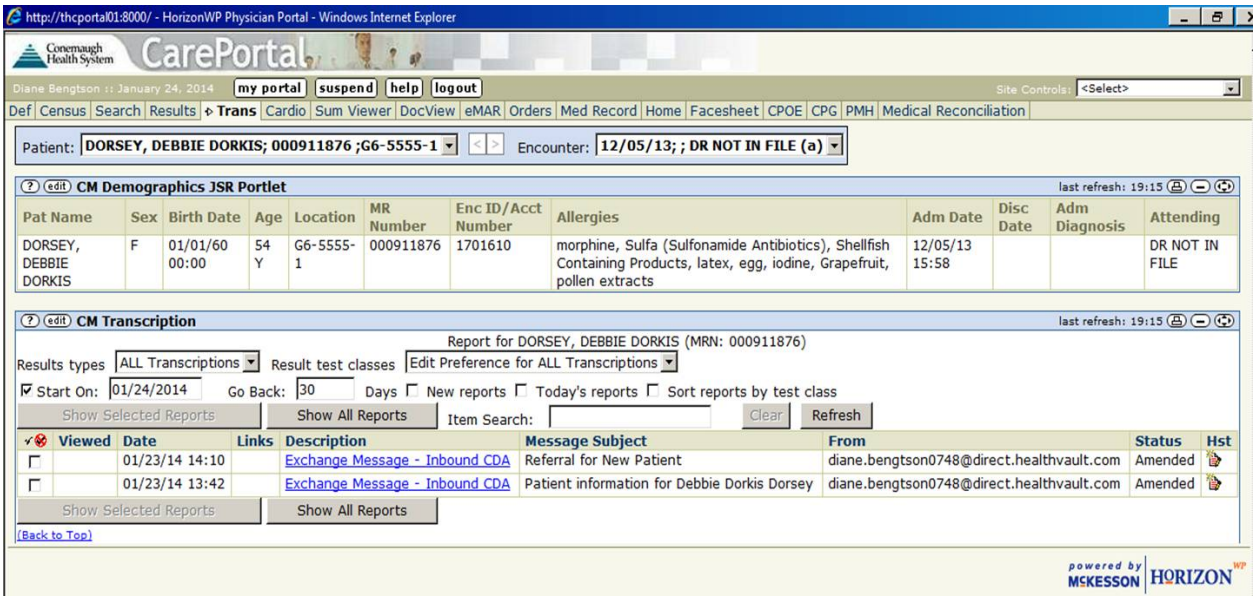



**Figure 62. Inbound CDA Message Exchange.**

Hard copy printing is enabled, as well as the ability to send important information to the patient's electronic McKesson chart for review and reconciliation by the nursing staff. Information may include: problems, allergies, medications, etc.

*Direct Exchange Push Outbound*

Conversely, CHS providers can also push CDA documents to external providers and patient portals. The specific workflow is outlined in Appendix R.

*Query-based Exchange*

The VLER Exchange architecture uses secure robust eHealth Exchange protocols and standards to support query-based exchange use cases nationwide. In our case, interoperable data exchange supports the treatment of veterans in Southwestern Pennsylvania between a private healthcare organization (i.e. Conemaugh) and the Department of Veterans Affairs. After receipt of the patient's authorization form, opt-in and successful correlation between organizations, Conemaugh providers can query the VA system via the CONNECT Universal Client GUI (Figure 63) for a C-CDA (Figure 64). Unstructured reports have recently been integrated into this document format as well.

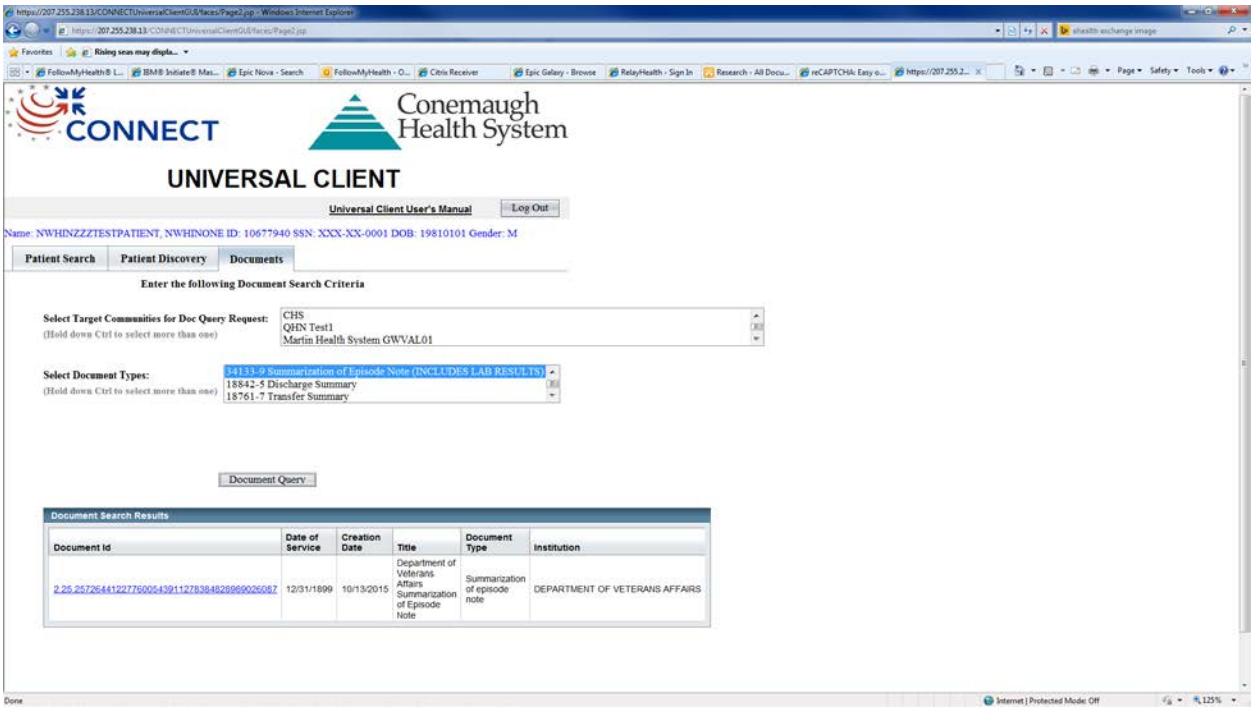



**Figure 63. C-CDA returned within CONNECT Universal Client GUI.**

Click on the hyperlink to view the document contents. Print and scan as needed.

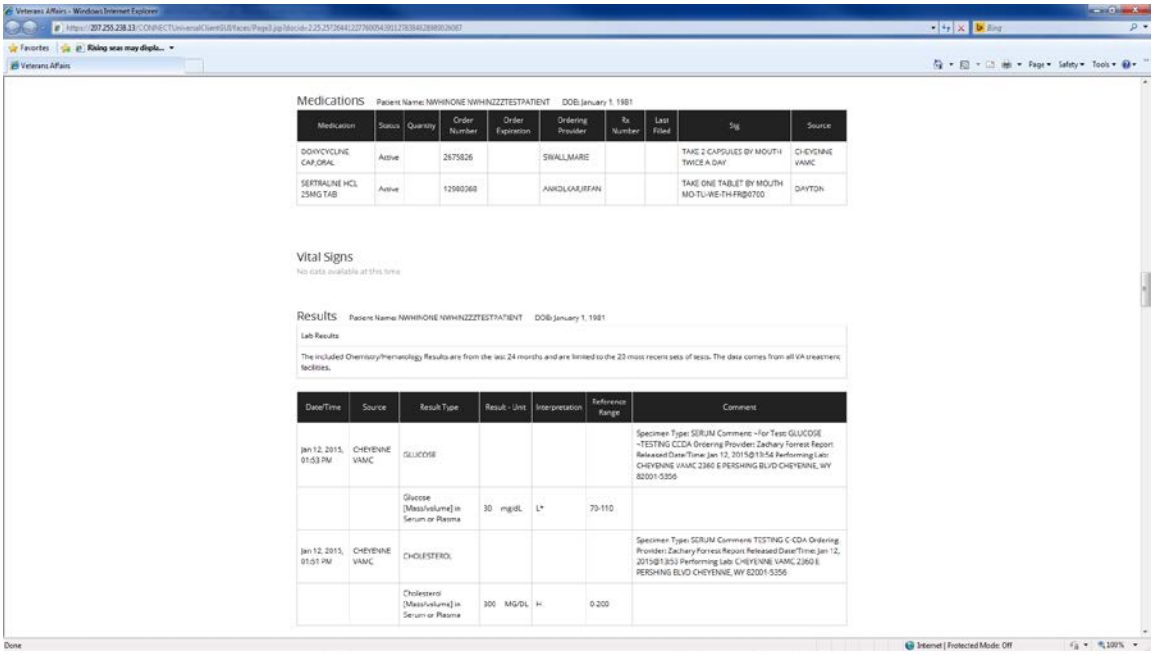



**Figure 64. Sample C-CDA document.**

VA providers follow a similar process using VistAWeb (Figure 65).

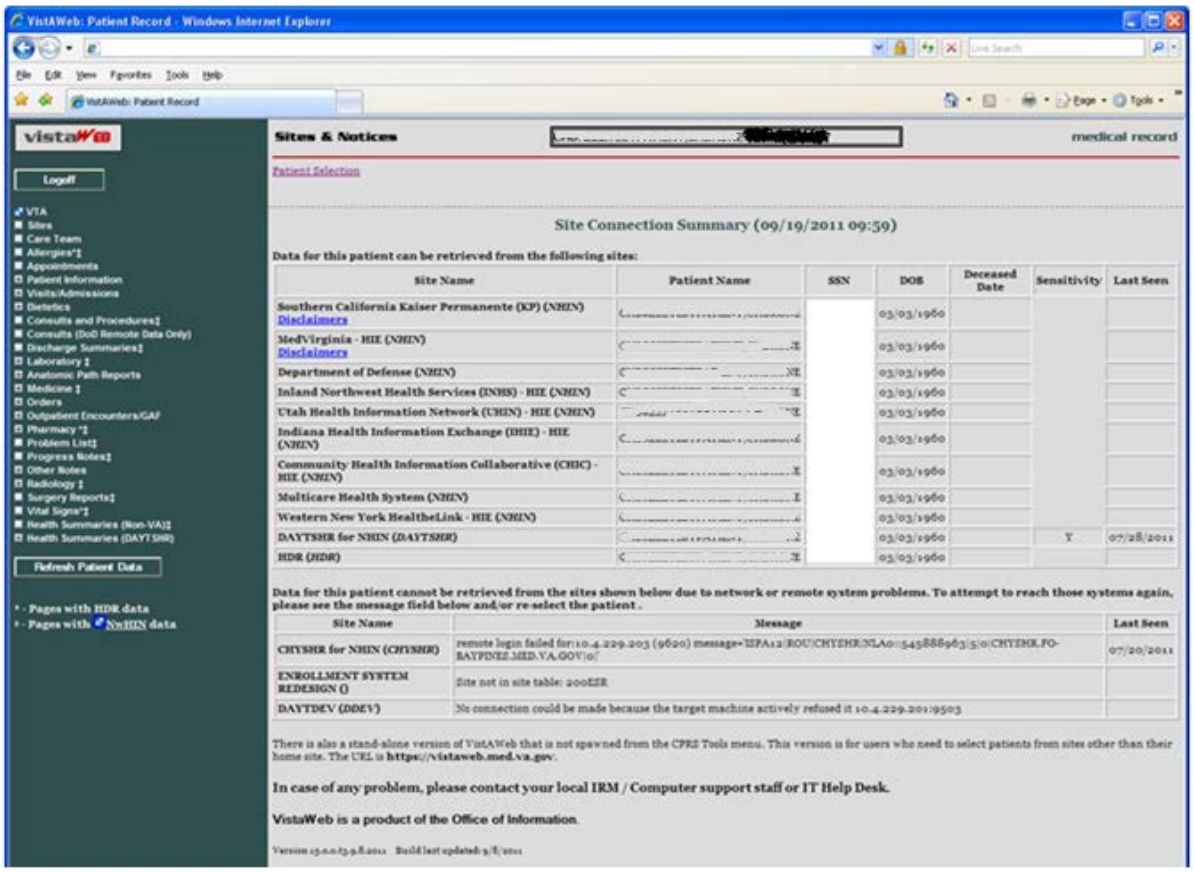



**Figure 65. VistAWeb from VA.**

The following table (Table 39) compares the pros and cons of each approach. Ideally, the approach chosen will depend on the specific use case and the available resources to support the infrastructure.

| | Pros | Cons |
|---|---|---|
| **Direct Exchange** | C-CDA structured in human readable format | No easy lookup to determine Direct Exchange address, contact provider for information |
| | No MPI matching needed | Limited push availability in rural areas (IT support and knowledge challenging) |
| | Authorization covered under standard hospital releases | Manual process that requires a staff resource 24 x 7 to push documents to parties |
| | Technical uplift much lighter | Multiple connection failure points in reception (e.g. manual pushes vs. interface) |
| | Date ranges configurable | |
| | Set automatic triggers when updates made in the record for push function | |
| **Query-based Exchange** | Clinical information provided quickly to treating provider when needed | Technical uplift much greater |
| | Various document types available (e.g. C-CDA, C32, C62) | Requires skilled programmers and knowledgeable contractors |
| | Consent improves patient awareness of | MPI matching required between systems |

| | | |
|---|---|---|
| | initiative | (correlation) |
| | 100+ organizations in the network, including government agencies | Patient authorization time-consuming and laborious |
| | Avoids building custom interfaces with trading partners | Identification of correlated patients to end users can be tricky |
| | Mature trust policies that are widely adopted (e.g. DURSA) | |

**Table 39. Direct based vs. Query based Exchanges.**

### *Subtask 2.2 Provide technical and documentation assistance on DoD-managed Virtual Lifetime Electronic Record (VLER) efforts.*

******No specific tasking was identified by TATRC for this contract******

### *Subtask 2.3 Investigate productizing a Patient Consent module using established standards, such as TP20/XACML.*

Conemaugh and NGC agreed to participate in the Jericho/UT-Austin DS4P Pilot in July 2012 by serving as a test CONNECT gateway on a simulated eHealth Exchange. Pilot work was not initiated until April 2013 due to contracts and funding issues. Information about the pilot can be found at: http://wiki.siframework.org/Data+Segmentation+for+Privacy+Homepage

The pilot explored 12 electronic exchange scenarios and eight types of data transactions. Pilot participants performed various roles to test these scenarios. Jericho Systems served as primary custodian of the patient's record and housed the Patient Consent Directive (PCD) repository. The University of Texas at Austin HIT Program simulated the role of a research university that requested the patient's record and subsequently acted as the secondary custodian of the information. Conemaugh played the role of a marketing network that became the second requestor.

In support of the DS4P J-UT pilot, a CentOS Virtual Machine (VM) image was successfully retrieved from Jericho and installed on a MIDHT test sever in August 2013. Once installed, the GlassFish server contained within the VM was configured to use ports 443 and 80 instead of ports 8181 and 8080.

NCG additionally helped the Jericho technical team establish a GoTo Meeting session that was used to support the Jericho/UT-Austin Pilot use-case demonstration (September 19, 2013). NGC continued to provide support to Jericho until contract expiration.

### *Subtask 2.4 Assess and analyze NwHIN-related activities, to include data center performance metrics, physician evaluation and usage of the NHIN Portal, and resulting benefits of HIE with federal participants.*

#### 2.4.1 Patient Correlations (Patient Discovery)

As previously discussed in Subtask 2.1.1 (VLER Exchange Activities - Conemaugh and James E. Van Zandt

VA Medical Center), patient correlations were seemingly dependent on the patient response to direct postal mailings of VLER recruitment packets. Of important note, failed patient correlations were often less than 5%; again likely resulting from inclusion of the patient Social Security Number during the matching process. This rate is lower than that noted through anecdotal discussions with other sites. Statistics are highlighted below in Table 40 and Table 41.

**Statistics**

| | | Monthly_Count_correl | Monthly_Count_Returned_Auths | Count_Opted_IN_by_month | Count_Discovered_by_month |
|---|---|---|---|---|---|
| N | Valid | **41** | **41** | **41** | **41** |
| | Missing | **0** | **0** | **0** | **0** |
| Mean | | **27.68** | **28.05** | **27.71** | **27.68** |
| Median | | **12.00** | **12.00** | **11.00** | **12.00** |
| Mode | | **0** | **0** | **0** | **0** |
| Sum | | **1135** | **1150** | **1136** | **1135** |

**Table 40. Patient Correlation Statistics.**

| | | Sex_male | Sex_female | Age_AVG_Opt_IN_yrs | AVG_days_bw_PT_disc_OPT_in |
|---|---|---|---|---|---|
| N | Valid | **41** | **41** | **36** | **36** |
| | Missing | **0** | **0** | **5** | **5** |
| Mean | | **26.90** | **.80** | **69.47** | **15.47** |
| Median | | **10.00** | **.00** | **70.23** | **11.18** |
| Mode | | **0** | **0** | **55.53** | **.0000** |
| Sum | | **1103** | **33** | **2501.01** | **556.87** |

**Table 41. Patient Correlation Demographics.**

### 2.4.2 Patient Survey

A total of 119 Veterans submitted responses to the survey and 97% consented to share their health information with NwHIN participants. When asked if they felt their health information was secure and private, 72% answered YES and 28% were NOT SURE. Forty-four percent of the patients said that their providers talked about the new service (NwHIN exchange) during their appointment. This implies that the patient perception of security and privacy was independent of provider discussion of health information exchange.

Respondent Demographics:

- 95% (112/118) were male
- 89% (106/119) were 61 years or older, with the remaining age 18 – 60

Veterans responding to the survey have had a positive experience with health information exchange between Altoona VA and Conemaugh. Over 60% of patients believe that coordination of care across providers has improved. Similar percentages were obtained regarding reducing the need for Veterans to hand carry their paper records to providers and less duplicate testing. Of note for those that chose these three benefits, at least 72% of the respondents also felt their health information was secure and

private. More than half of survey respondents believe that decision making and quality of care has also improved (Figure 66).

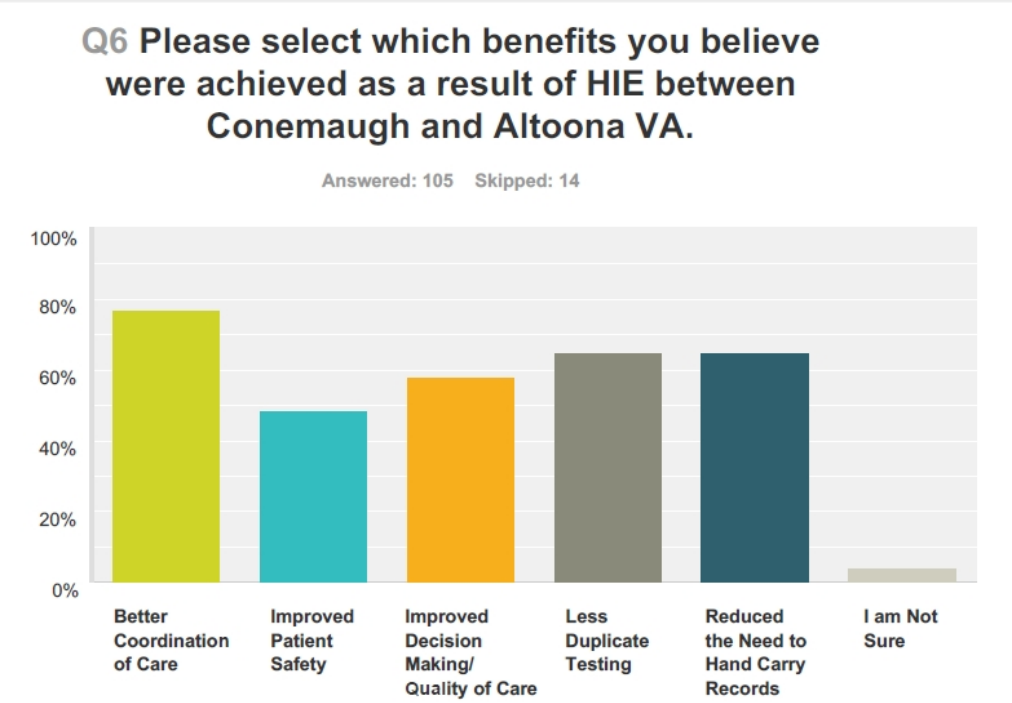



**Figure 66. Patient Perceived Benefits of Health Information Exchange (HIE).**

### 2.4.3 Provider Survey

Twenty-three providers, 96% Family Medicine/Primary Care and 4% Internal Medicine, submitted responses to the survey, with 91% being employed by the Conemaugh Health System and 9% employed by an independent practice. The Altoona VA did not provide permission to survey their users, which was unfortunate. Respondents self-identified as a member of one of the following categories, physician (17%), clinical staff (43%), clerical staff (30%) and administration (9%). The distribution of the respondents' years of experience follows (Figure 67):

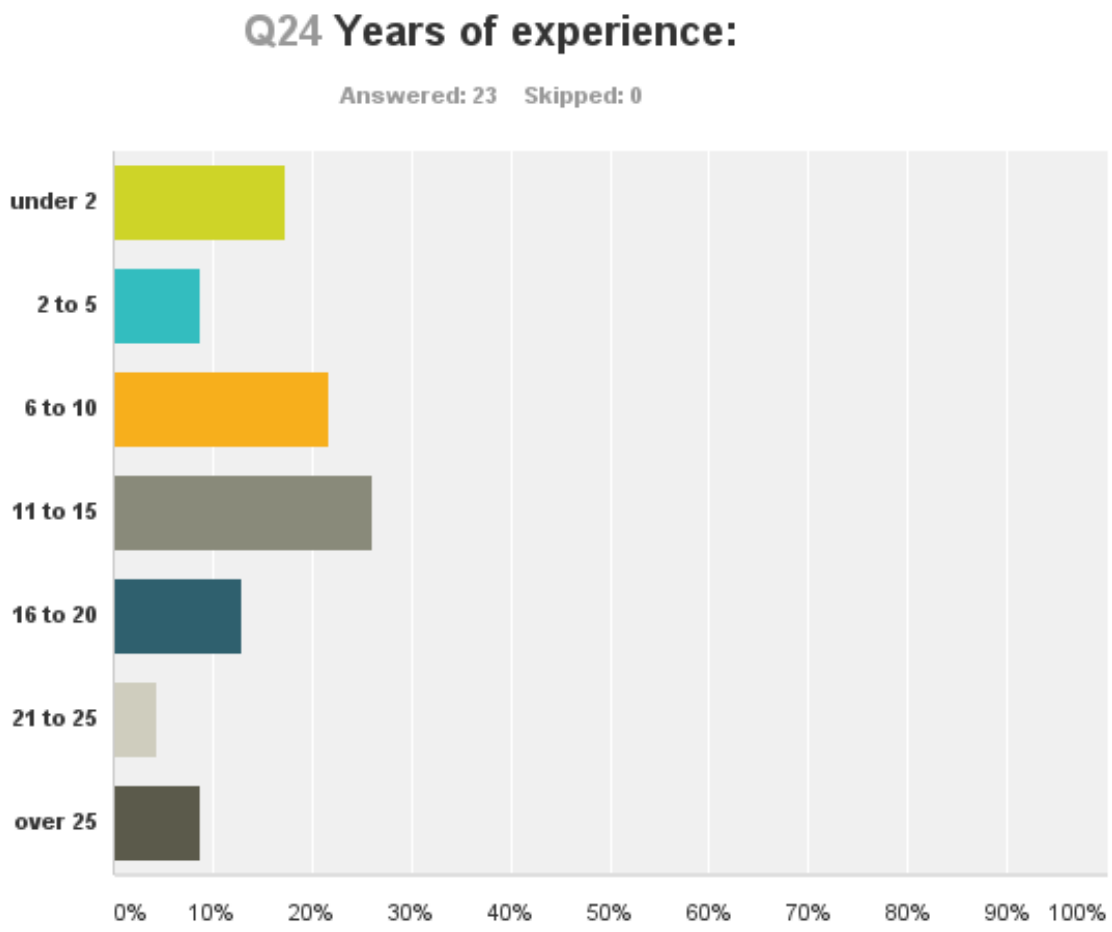



**Figure 67. Provider Years of Experience.**

Most of those surveyed, 61% (14/23), indicated that they accessed PHI through the NwHIN/VLER Exchange. For those who did not (n=9), 44% responded that they 'did not treat Veterans', 33% as 'not having time', and 22% believed 'additional training was needed' (Q04) - consistent with 79% of respondents having found the training/user manual helpful (Q22). Nearly all those who indicated using the service (93%) believed they understood the steps needed to retrieve a clinical document (Q20). Seventy-nine percent accessed information from their personal office while the remaining 21% did so from a clinic/unit/ or patient floor (Q05). The types of documents accessed were as follows (Q11)(Figure 68):

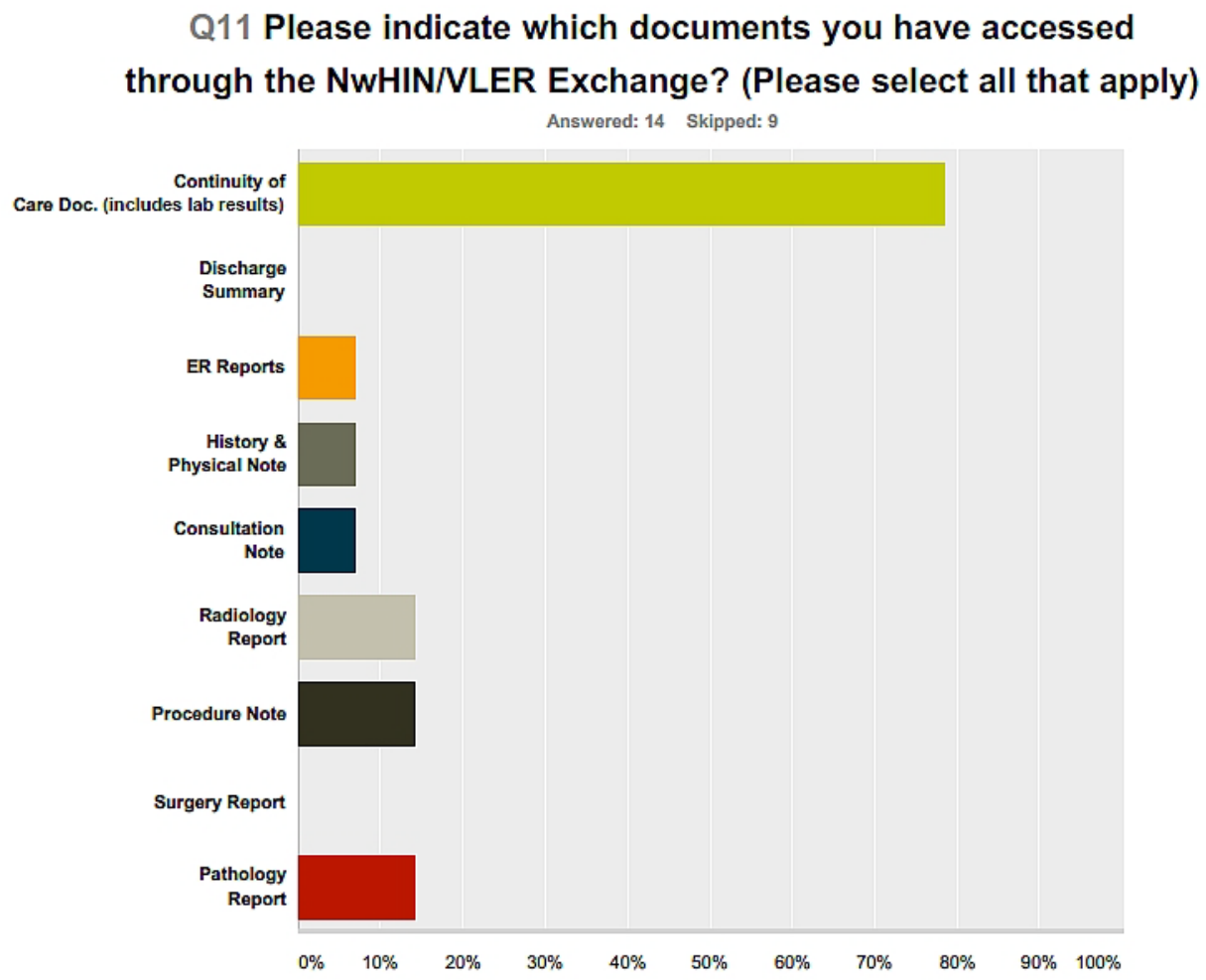



**Figure 68. Provider Exchange Document Type.**

When asked about the usability of the service, the provider participants replied as follows (Figure 69):

- 64% agreed that the GUI is clean and easy to navigate (Q19)
- 86% agreed that clinical data is presented in a readable format (Q21)
- 50% perceived the processing time of a document query to be between 2 – 5 minutes (Q14)
- 36% perceived the processing time of a document query to be between ½ and 2 minutes

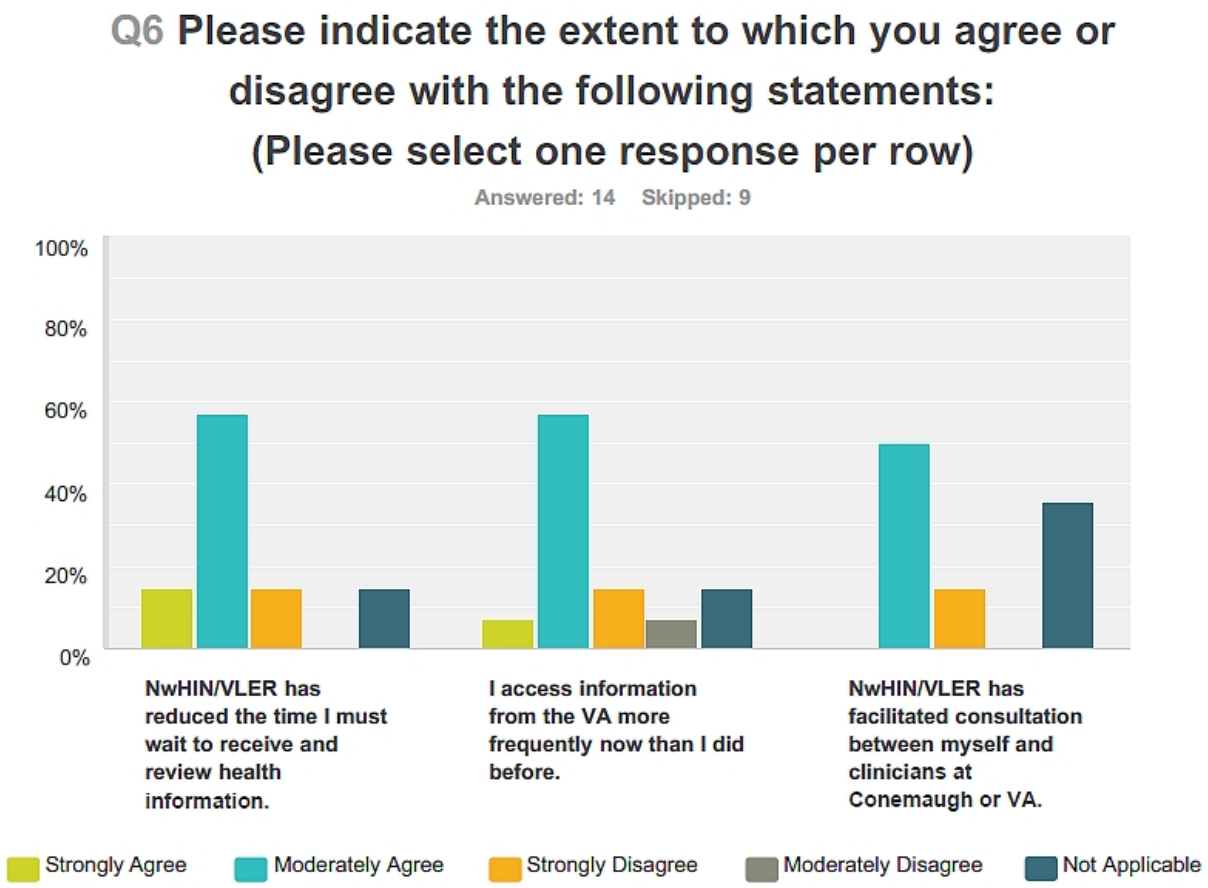



**Figure 69. Provider Satisfaction.**

The graph above is consistent with 79% (11/14) being in agreement that they are more satisfied with HIE exchange via NwHIN compared to previous routines, e.g. fax, postal mail, etc. (Q17). Insight into this satisfaction score is detailed in the following graph asking about perceived benefits of the service. Note, the responses to the perceived benefits under consideration above were not mutually exclusive.

Perceived benefits of the NwHIN/VLER Exchange were as follows:

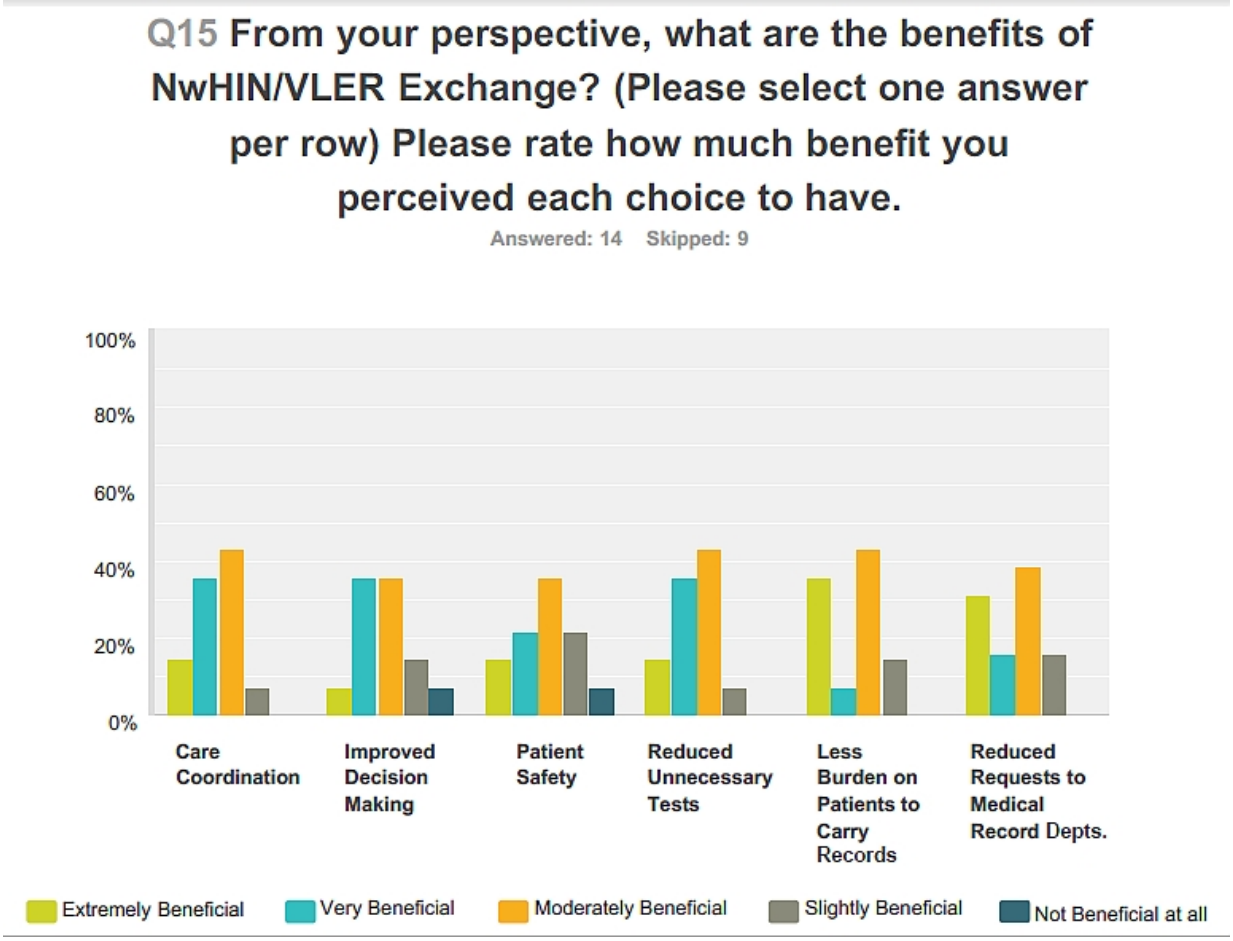



**Figure 70. Perceived Benefits of eHealth Exchange.**

The perceived benefits shown above (Figure 70) are underscored given that 78% agreed that HIE reduced the reordering of tests (Q09); and 57% agreed that access to documents from remote sites (enabled by HIE via NwHIN/VLER) improved their ability to make decisions regarding patient care - 36% replied that this question was not applicable (Q08).

Although the majority of providers were satisfied (overall) with the service and found it to be beneficial, fifty percent agreed that the NwHIN/VLER service improved their productivity while 43% disagreed (Q07).

Note, the responses to the perceived benefits under consideration above were not mutually exclusive. Additional cross tab analyses are located in Appendix S.

### 2.4.4 Data Center Performance Metrics

NGC provided a sampling of monitoring statistics from the Glassfish server throughout its subcontract.

Glassfish metrics can be found in Table 42 and Figure 71. Although not continuous, the three presented time periods represent all the time periods received from NGC. Noteworthy is the nearly doubling of created connections with a concurrent precipitous drop in the rate of severe log errors/uptime.

| | GF1 | GF2 | GF3 |
|---|---|---|---|
| Log Start Date | 12/19/2012 | 3/20/2013 | 7/23/2013 |
| Log End Date | 1/16/2013 | 5/8/2013 | 9/16/2013 |
| Log Level Error = SEVERE | 129 | 48 | 1 |
| UPTIME, days | 28.0 | 48.0 | 54.9 |
| SEVERE Log Level Errors/ (UPTIME, days) | 4.60 | 1.0 | 0.02 |
| Count OVERflows | 0 count | 0 count | 0 count |
| Request Load | | | |
| # connections created | 12062 Count | 19250 Count | 23640 Count |
| MAXtime (bean-pool), minutes | | | |
| Runtime-http-listener 1 | 1.3 | 3.1 | 8.5 |
| Runtime-http-listener 2 | 1.3 | 2.8 | 8.5 |
| Runtime-http-listener 3 | 0 | 0 | 0 |

**Table 42. Glassfish Metrics.**

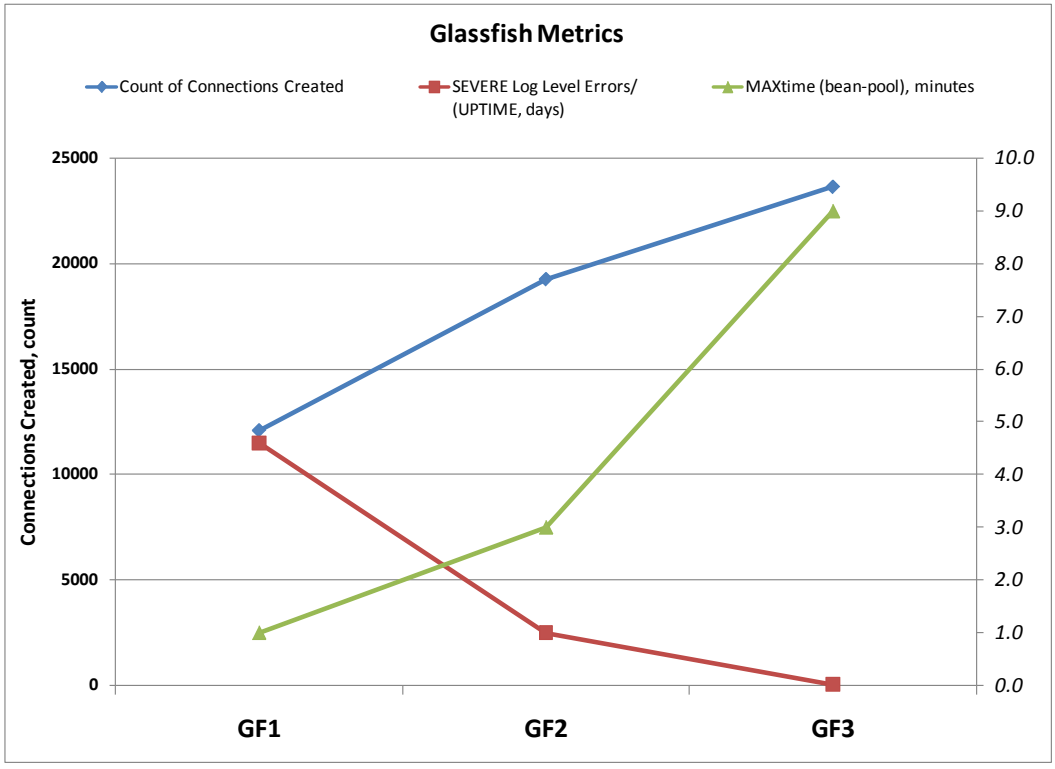



**Figure 71. Glassfish Metrics by Time Period.**

**Protocol A-16192.3** has maintained local IRB and secondary approval status. The document received initial approval from MMC Scientific Review Committee (July 12, 2012) and local CONEMAUGH IRB approval one week later (July 17, 2012). USAMRMC IRB approval was received on August 13, 1012.

**Protocol A-16192.3 Institutional Review Board Timeline**

- Received initial Conemaugh approval of protocol (July 17, 2012)
- Received initial USAMRMC HRPO approval of protocol (August 13, 2012)
- Received Conemaugh continuing review (July 16, 2013)
- Received acknowledgement of continuing review receipt by USAMRMC HRPO (July 24, 2013)
- Received Conemaugh continuing review (July 8, 2014)
- Received acknowledgement of continuing review receipt by USAMRMC HRPO (July 28, 2014)
- Received Conemaugh continuing review (July 7, 2015)
- Pending acknowledgement of continuing review receipt by USAMRMC HRPO (submitted by Conemaugh July 28, 2015)

**Conclusion**

Concurrent use of VA and non-VA health care services is high among rural veterans. Of the 9.1 million people enrolled in VA healthcare benefits (VHA Office of Rural Health). 3.2 million, or roughly 35% live in rural communities (Veterans Health Administration, Support Services Center). Over 20% of these enrollees living in rural areas are more the 60 minutes away from a VA Medical Center (over 40% live more than 90 minutes away). Given existing transportation challenges of many veterans and their need for multi-disciplinary and/or specialist care, health information exchange between VA and non-VA providers is essential for care coordination and medical co-management. Non-VA providers generally view the VA as the barrier to collaborative care and information sharing (Gaglioti A)(Lampman 2011) and note the patient is the main vehicle of health information exchange between health systems and providers (Nayar P). NwHIN, now eHealth Exchange, was one technically driven project established to create shared exchanges of health information.

At the conclusion of the MIDHT program, Conemaugh has successfully established a production exchange of live patient data via the eHealth exchange as well as:

- Incorporated data domains from both Allscripts (Out Patient) and McKesson (In Patient) Electronic Health Record (EHR) systems
- Provided on ONC supported pilot for electronic patient consent
- Contributed code products to the open-source community
- Achieved CCHIT accreditation/certification.

In support of the eHealth Exchange mission, the MIDHT program has established a “Gateway” that serves as an onramp to the eHealth Exchange network.

Though MIDHT addressed barriers to communication through the establishment of the health data exchange, the project did not overcome some of the commonly reported problems with better care coordination between VA and non-VA providers. Though project education initiatives, incentives, outreach, and systems based improvements were completed, usage by the Conemaugh providers was minimal. Patient and provider satisfaction was recognized, however, improved care coordination and veteran health outcomes sadly failed to motivate usage within our own health system.

One overall, broad based note on the MIDHT project implementation that proved to be the biggest obstacle was the fact that HIE is not a primary focus of our organization (Conemaugh). Challenges therefore existed internally to redirect system priorities away from patient portals and general operative system exchanges (i.e e-prescribing, notes, etc) within our IT department. Work within MIDHT fell outside the scope of standard daily operations.

Lessons learned are not dissimilar to those learned by the Department of Veterans Affairs (Bouhaddou O)(Byrne CM)(Mueller KJ). Shared lessons include overall data quality and interoperability challenges (Botts N), specifically:

- The vital importance of workflow engineering.
- Integration of electronic health records is time intensive.
- Standards specifications and best practices are notwithstanding and this inevitably slows integration progress. There is a direct need to better metrics for health record interoperability,
- Compliance challenges, as Conemaugh signed the DURSA, but it was also necessary that project vendors also be in compliance.
- Privacy issues between partnering organizations can stifle advancement
- The involvement of integrating new systems and working relationships between partners include discussions on the format, content, and parameters of information that is to be exchanged.

Like other reviews of HIE (Rudin RS), our stakeholders found value in health information exchange, but barriers of acceptance and usage existed. Technical and workflow issues were problematic, but in the end, these were more easily overcome rather than stakeholder engagement. More research is needed on identifying success factors and operational issues.

## *Key Research Accomplishments*

- Successfully deployed an integrated pharmacy robotics and bar code medication administration technology platform throughout three Conemaugh hospitals
- Completed an extensive research analysis of the impact of said technology on medication errors, provider satisfaction, workflow and financial metrics
- Conemaugh became the 14$^{th}$ Virtual Lifetime Electronic Record pilot in the nation; partnering with the Department of Veterans Affairs in production for three years
- Integrated the open source CONNECT software with three commercial EHR systems utilizing significant custom build
- Enrolled over 1,000 Veterans in the program for health information exchange
- First participant in the nation to successfully pass new “eHealth Exchange” testing program (2010/2011 services)
- 99% patient discovery correlation rate

## *Reportable Outcomes*

- Presented in annual research poster symposiums, multiple HIMMS Interoperability Showcases, CONNECT Code-A-Thons, patient safety fairs, direct and indirect community outreach efforts,

and community response veterans conferences co-sponsored by the Veterans Community Initiatives (VCI, Johnstown, PA; http://www.vciinc.org)

- Made multiple CONNECT code contributions to TATRC, Federal Health Architecture and Alembic Foundation

## *Conclusion*

Conemaugh Memorial Medical Center has completed both arms of the MIDHT project within the POP. Statement of Work (SOW) tasks were all successfully executed. Core technologies under investigation included pharmacy robotics, bar code medication administration (BCMA) and health information exchange via the eHealth Exchange.

Implementation of an automated pharmacy robotics system and complementary bedside BCMA technology at three hospitals was a significant undertaking that directly resulted in new workflows for many healthcare staff and valuable lessons learned as noted. The research analysis produced varied results with an overall neutral impact on medication error rates, nursing satisfaction and provider workflow.

The program has evolved from a testbed to a production exchange of data between a rural health system and the VA. The program is regarded as the 14$^{th}$ VLER pilot, supports meaningful use criteria, and is one of the first to adopt both the 2010 and 2011 eHealth exchange specifications. Though data from the 2009-2013 Electronic Health Records Survey concluded the electronic health record adoption continues to develop in terms of usage and acceptance, only 14% share data with providers outside their organization (Furukawa MF). Conemaugh was pleased to establish exchange with the James E. Van Zandt VA Medical Center. As a major healthcare provider for veterans in southwestern Pennsylvania, Conemaugh needs to continue to develop working relationships with outside providers to enable more seamless care transitions via technology and electronic health records systems. Lessons learned from MIDHT will continue to shape our progress.

# References


Agency for Healthcare Research & Quality. <http://healthit.ahrq.gov/ahrq-funded-projects/emerging-lessons/bar-coded-medication-administration>.

Botts N, Bouhaddou O, Bennet J, Pan E, Byrne C, Mercincavage L, Olinger L, Hunolt E, Cullen T. "Data quality and interoperability challenges for eHealth Exhange participants: Observations from the Department of Veterans Affairs' Virutal Lifetime Electronic Record health pilot phase." AMIA Annual Symposium Proceedings (2014): 307-314.

Bouhaddou O, Bennet J, Teal J, Pugh M, Sands M, Fontaine F, Swall M, Dhar S, Mallia T, Morgan T, Cromwell T. "Toward a virtual lifetime electronic record: The Department of Veterans Affairs experience with the Nationwide Health Information Network." AMIA Annual Symposium Proceedings (2012): 51-60.

Byrne CM, Mercincavage LM, Bouhaddou O, Bennet JR, Pan EC, Botts NE, Olinger LM, Hunolt E, Banty KH, Cromwell T. "The Department of Veterans Affairs' (VA) implementation of the Virtual Lifetime Electronic Record (VLER): Findings and lessons learned from Health Information Exchange at 12 sites." International Journal of Medical Informatics (2014): 537-547.

Franklin BD, O'Grady K, Donya IP, et al. "The impact of a closed-loop electronic prescribing and administration system on prescribing errors, administration errors and staff time: a before and after study." Quality & Safety in Healthcare, 16 (2007): 279-284.

Furukawa MF, King J, Patel V, Hsiao C-J, Alder-Milstein A, Jha AK. "Despite substantial progress in EHR adoption, Health Information Exchange and patient engagement remain low in office settings." Health Affairs (2014): 1672-1679.

Gaglioti A, Cozad A, Wittrock S, Stewart K, Lampman M, Ono S, Schacht Reisinger H, Charlton ME. "Non-VA Primary Care Providers' Perspectives on Comanagement for Rural Veterans." Military Medicine (2014): 1236-1243.

Halbesleben JRB, Savage GT, Wakefield DS, Wakefield BJ. "Rework and workarounds in nurse medication administration process: implications for work processes and patient safety." Health Care Management Review, 35.2 (2010): 124–133.

Hassink J, Jansen M, Helmons P. " Effects of bar code-assisted medication administration (BCMA) on frequency, type, and severity of medication administration errors: a review of the literature." European Journal of Hospital Pharmacy 19 (2012): 489-494.

Holden RJ, Brown RL, Alper SJ, Scanlon MC, Patel NR, Karsh BT. "That's nice, but what does IT do? Evaluating the impact of bar coded medication administration by measuring changes in the process of care." International Journal of Industrial Ergonomics 41.4 (2011): 370–379.

Hook JM, Pearlstein J, Samarth A, Cusak, C. "Using barcode medication administration to improve quality and safety." 2008.

Hurley A, Lancaster D, Hayes J, Wilson-Chase C, Bane A, Griffin M, Warden V, Duffy ME, Poon EG, Gandhi TK. "The medication administration system-Nurses assessment of satisfaction (MAS-NAS) scale." Journal of Nursing Scholarship 38.3 (2003): 298-300.

Lampman MA, Mueller KJ. "Experiences of rural Non-VA providers in treating dual care veterans and the developmentof electronic health information exchange netwroks between the two systems." Journal of Rural Social Science (2011): 201-209.

Lewis PJ, Dornan T, Taylor D, Tully MP, Wass V, Ashcroft DM. "Prevalence, incidence and nature of prescribing errors in hospital inpatients." Drug Safety 32.5 (2009): 379-389.

Miller, DF, Fortier, CR, & Garrison, KL. "Bar code medication administration technology: Characterization of high-alert medication triggers and clinician workarounds." The Annals of Pharmacotherapy 45.2 (2011): 162–168.

Morris FH, Abramowitz PW, Nelson SP, et al. "Effectiveness of a bar-code medication administration system in reducing preventable adverse drug events in a neonatal intensive care unit: a prospective cohort study." Journal of Pediatrics 154 (2009): 363-368.

Mueller KJ, Lampman M. "Electronic Health Information Exchange between VHA system and private providers." 2011.

Nayar P, Nguyen AT, Ojha D, Schmid KK, Apenteng B, Woodbridge P. "Transitions in dual care for veterans: non federal physicians perspectives." Journal of Community Health (2013): 225-237.

Pedersen CA, Schneider PJ, Scheckelhoff DJ,. "ASHP national survey of pharmacy practice in hospital settings: Dispensing and administration—2011,." American Journal of Health-System Pharmacy. 69.9 (2012): 768-785.

Poon EG, et al. "Impact of barcode medication administration technology on how nurses spend their time providing patient care. ." J Nurs Adm. (2008 Dec): 38(12): 541-549.

Poon EG, Keohane CA, Yoon CS et al. "Effect of bar-code technology on the safety of medication administration." New England Journal of Medicine 362 (2010): 1698-1707.

PRNewswire-USNewswire. <http://www.prnewswire.com/news-releases/new-aarp-report-brand-name-drug-prices-increasing-dramatically-283312371.html>.

Rack, L, L Dudjak and G. & Wolf. "Study of nurse workarounds in a hospital using bar code medication administration system." Journal of Nursing Care Quality 27.3 (2012): 232-239.

Rudin RS, Motala A, Goldweig C, Shekelle PG. "Usage and effect of Health Information Exchange: a systematic review." Annals of Internal Medicine (2014): 803-811.

Shane, R. "Current status of administration of medicines." American Journal of Health- System Pharmacy 66.5 (2009): s42–s48.

Veterans Health Administration, Support Services Center. n.d.

VHA Office of Rural Health. "Office of Rural Health: At a Glance." 2015.

Wideman, MV, Whittler, ME ME and TM Anderson. "Barcode Medication Administration: Lessons Learned from an Intensive Care Unit Implementation." Wideman MV, Whittler ME, Anderson TM. Advances in Patient Safety: From Research to Implementation. Ed. Whittler ME, Anderson TM. Barcode Medication Administration: Lessons Learned from an Intensive Care Unit Implementation. In: Henriksen K, Battles JB, Marks ES, et al. (Wideman MV. Vol. 3. Rockville: Agency for Healthcare Research and Quality, 2005.

Yang, Z, et al. "Workarounds in the use of IS in healthcare: A case study of an electronic medication administration system." International Journal of Human-Computer Studies 70.1 (2012): 43–65.

**Appendix A. Lists of acronyms and abbreviations.**

| Acronym | Description/Definition |
|---|---|
| API | Application Programming Interface |
| BCMA | Bar Code Medication Administration |
| CAL | Common Access Layer |
| CHS | Conemaugh Health System |
| MMC | Conemaugh Memorial Medical Center |
| COTS | Commercial Off The Shelf |
| CPP | Consumer Preferences Profile |
| CVMH | Conemaugh Valley Memorial Hospital (dba "CONEMAUGH") |
| DQ | Document Query |
| DoD | Department of Defense |
| FHA | Federal Health Architecture |
| GUI | Graphical User Interface |
| HAPI | HL7 Application Programming Interface |
| HIE | Health Information Exchange |
| JIRA | Bug tracking software |
| JKS | Java KeyStore |
| LDAP | Lightweight Directory Access Protocol |
| MHS | Military Health System |
| MIMC | Conemaugh Miners Medical Center |
| MIDHT | Military Interoperable Digital Hospital Testbed |
| MIS | Management Information Systems |
| MPI | Master Patient Index |
| MYMC | Conemaugh Meyersdale Medical Center |
| NGC | Northrop Grumman Corporation |
| NIST | National Institute of Technology |
| NwHIN | Nationwide Health Information Network (now called "eHealth Exchange") |
| OID | Object Identifier |
| ONC | Office of the National Coordinator for HIT |
| OpenDS | Open Directory Service |
| PD | Patient Discovery |
| PHI | Protected Health Information |
| QD | Query for Documents |
| RD | Retrieve Documents |
| SAML | Security Access Markup Language |
| SAN | Storage Area Network |
| SOW | Statement of Work |
| SSO | Single Sign On |
| SSL | Secure Socket Layer |

| | |
|---|---|
| SVN | Subversion |
| TATRC | Telemedicine & Advanced Technology Research Center |
| UC | Universal Client |
| UDDI | Universal Description Discovery and Integration |
| USAMRMC | United States Army Medical Research and Materiel Command |
| VA | U.S. Department of Veterans Affairs |
| VLER | Virtual Lifetime Electronic Record |
| VPN | Virtual Private Network |
| WSDL | Web Services Description Language |
| XDS | Cross-Enterprise Document Sharing |

**Appendix B. Pharmacy Robotics Equipment (MMC)**


**Pharmacy Robotics Equipment**

**Appendix C. AdminRX Analytics Screenshots.**

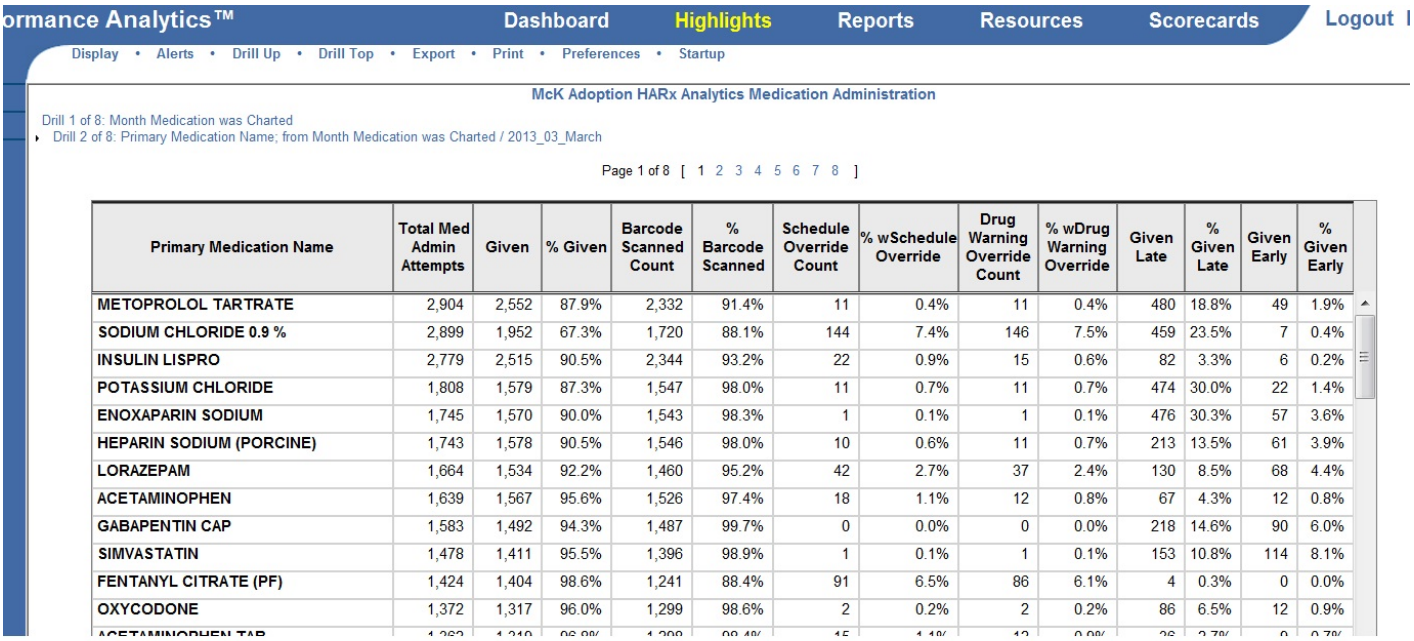
**McK Adoption Horizon AdminRx Analytics**

Entity: 01 Refresh

Department: Show All

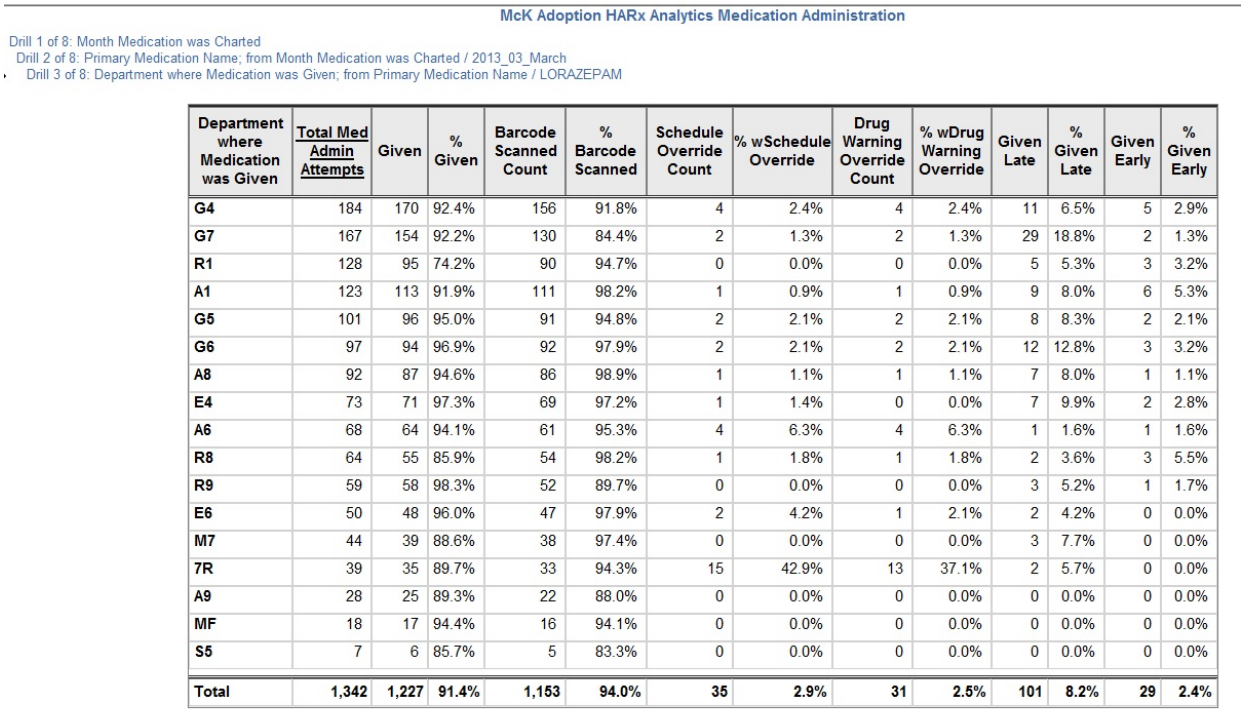
| Measure | Previous 5 Months | | | | | | Current Month | Goal | Achievement |
|---|---|---|---|---|---|---|---|---|---|
| | Nov 2012 | Dec 2012 | Jan 2013 | Feb 2013 | Mar 2013 | | | | |
| | **Medication Administration** | | | | | | | | |
| **Total # of Med Admin Attempts** | ‡ | ‡ | 315,216* | 184,894* | 156,625* | | 36,156* | | |
| **% Med Admins Given** | ‡ | ‡ | 85.7%* | 84.6%* | 84.0%* | | 83.8%* | | |
| **% Med Admins w/Drug Barcode Scanned** | ‡ | ‡ | 95.7%* | 95.0%* | 94.3%* | | 94.5%* | | |
| **% Med Admins Given Early** | ‡ | ‡ | 3.6%* | 4.1%* | 5.0%* | | 4.3%* | | |
| **% Med Admins Given Late** | ‡ | ‡ | 14.1%* | 15.8%* | 16.7%* | | 16.7%* | | |
| **% Admins wNo Med Order Found Override** | ‡ | ‡ | 1.1%* | 1.2%* | 1.3%* | | 1.3%* | | |
| **% Admins w/ Quantity Override** | ‡ | ‡ | 0.7%* | 0.7%* | 0.7%* | | 0.6%* | | |
| **% Admins w/No Schedule Found Override** | ‡ | ‡ | 1.2%* | 1.3%* | 1.4%* | | 1.4%* | | |
| | **Medication Administration Warnings** | | | | | | | | |
| **Total # of Med Admin Warnings** | ‡ | ‡ | 180,638* | 126,397* | 112,451* | | 25,483* | | |
| **% Med Admin Warnings Overridden** | ‡ | ‡ | 44.6%* | 48.3%* | 48.9%* | | 47.3%* | | |
| **% Med Admin Warnings Leading to Modify** | ‡ | ‡ | 52.4%* | 48.7%* | 48.5%* | | 49.8%* | | |
| **% Med Admin Warnings Leading to Cancel** | ‡ | ‡ | 52.4%* | 48.7%* | 48.5%* | | 49.8%* | | |
| | **IV Administration** | | | | | | | | |
| **Total # of IV Administrations** | ‡ | ‡ | 13,345* | 8,535* | 8,866* | | 1,910* | | |
| **% IV Admin Starts** | ‡ | ‡ | 48.1%* | 47.8%* | 48.3%* | | 49.3%* | | |
| **% IV Starts w/ IV Barcode Scanned** | ‡ | ‡ | 71.3%* | 63.3%* | 66.2%* | | 70.5%* | | |
| **% IV Admins w/ Wristband Scanned** | ‡ | ‡ | 88.9%* | 90.1%* | 90.2%* | | 89.1%* | | |

AdminRX Analytics Summary.




| Primary Medication Name | Total Med Admin Attempts | Given | % Given | Barcode Scanned Count | % Barcode Scanned | Schedule Override Count | % wSchedule Override | Drug Warning Override Count | % wDrug Warning Override | Given Late | % Given Late | Given Early | % Given Early |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METOPROLOL TARTRATE | 2,904 | 2,552 | 87.9% | 2,332 | 91.4% | 11 | 0.4% | 11 | 0.4% | 480 | 18.8% | 49 | 1.9% |
| SODIUM CHLORIDE 0.9 % | 2,899 | 1,952 | 67.3% | 1,720 | 88.1% | 144 | 7.4% | 146 | 7.5% | 459 | 23.5% | 7 | 0.4% |
| INSULIN LISPRO | 2,779 | 2,515 | 90.5% | 2,344 | 93.2% | 22 | 0.9% | 15 | 0.6% | 82 | 3.3% | 6 | 0.2% |
| POTASSIUM CHLORIDE | 1,808 | 1,579 | 87.3% | 1,547 | 98.0% | 11 | 0.7% | 11 | 0.7% | 474 | 30.0% | 22 | 1.4% |
| ENOXAPARIN SODIUM | 1,745 | 1,570 | 90.0% | 1,543 | 98.3% | 1 | 0.1% | 1 | 0.1% | 476 | 30.3% | 57 | 3.6% |
| HEPARIN SODIUM (PORCINE) | 1,743 | 1,578 | 90.5% | 1,546 | 98.0% | 10 | 0.6% | 11 | 0.7% | 213 | 13.5% | 61 | 3.9% |
| LORAZEPAM | 1,664 | 1,534 | 92.2% | 1,460 | 95.2% | 42 | 2.7% | 37 | 2.4% | 130 | 8.5% | 68 | 4.4% |
| ACETAMINOPHEN | 1,639 | 1,567 | 95.6% | 1,526 | 97.4% | 18 | 1.1% | 12 | 0.8% | 67 | 4.3% | 12 | 0.8% |
| GABAPENTIN CAP | 1,583 | 1,492 | 94.3% | 1,487 | 99.7% | 0 | 0.0% | 0 | 0.0% | 218 | 14.6% | 90 | 6.0% |
| SIMVASTATIN | 1,478 | 1,411 | 95.5% | 1,396 | 98.9% | 1 | 0.1% | 1 | 0.1% | 153 | 10.8% | 114 | 8.1% |
| FENTANYL CITRATE (PF) | 1,424 | 1,404 | 98.6% | 1,241 | 88.4% | 91 | 6.5% | 86 | 6.1% | 4 | 0.3% | 0 | 0.0% |
| OXYCODONE | 1,372 | 1,317 | 96.0% | 1,299 | 98.6% | 2 | 0.2% | 2 | 0.2% | 86 | 6.5% | 12 | 0.9% |
| ACETAMINOPHEN TAB | 1,363 | 1,319 | 96.8% | 1,299 | 98.4% | 15 | 1.1% | 12 | 0.9% | 36 | 2.7% | 0 | 0.7% |

AdminRX Analytics by Medication.




| Department where Medication was Given | Total Med Admin Attempts | Given | % Given | Barcode Scanned Count | % Barcode Scanned | Schedule Override Count | % wSchedule Override | Drug Warning Override Count | % wDrug Warning Override | Given Late | % Given Late | Given Early | % Given Early |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G4 | 184 | 170 | 92.4% | 156 | 91.8% | 4 | 2.4% | 4 | 2.4% | 11 | 6.5% | 5 | 2.9% |
| G7 | 167 | 154 | 92.2% | 130 | 84.4% | 2 | 1.3% | 2 | 1.3% | 29 | 18.8% | 2 | 1.3% |
| R1 | 128 | 95 | 74.2% | 90 | 94.7% | 0 | 0.0% | 0 | 0.0% | 5 | 5.3% | 3 | 3.2% |
| A1 | 123 | 113 | 91.9% | 111 | 98.2% | 1 | 0.9% | 1 | 0.9% | 9 | 8.0% | 6 | 5.3% |
| G5 | 101 | 96 | 95.0% | 91 | 94.8% | 2 | 2.1% | 2 | 2.1% | 8 | 8.3% | 2 | 2.1% |
| G6 | 97 | 94 | 96.9% | 92 | 97.9% | 2 | 2.1% | 2 | 2.1% | 12 | 12.8% | 3 | 3.2% |
| A8 | 92 | 87 | 94.6% | 86 | 98.9% | 1 | 1.1% | 1 | 1.1% | 7 | 8.0% | 1 | 1.1% |
| E4 | 73 | 71 | 97.3% | 69 | 97.2% | 1 | 1.4% | 0 | 0.0% | 7 | 9.9% | 2 | 2.8% |
| A6 | 68 | 64 | 94.1% | 61 | 95.3% | 4 | 6.3% | 4 | 6.3% | 1 | 1.6% | 1 | 1.6% |
| R8 | 64 | 55 | 85.9% | 54 | 98.2% | 1 | 1.8% | 1 | 1.8% | 2 | 3.6% | 3 | 5.5% |
| R9 | 59 | 58 | 98.3% | 52 | 89.7% | 0 | 0.0% | 0 | 0.0% | 3 | 5.2% | 1 | 1.7% |
| E6 | 50 | 48 | 96.0% | 47 | 97.9% | 2 | 4.2% | 1 | 2.1% | 2 | 4.2% | 0 | 0.0% |
| M7 | 44 | 39 | 88.6% | 38 | 97.4% | 0 | 0.0% | 0 | 0.0% | 3 | 7.7% | 0 | 0.0% |
| 7R | 39 | 35 | 89.7% | 33 | 94.3% | 15 | 42.9% | 13 | 37.1% | 2 | 5.7% | 0 | 0.0% |
| A9 | 28 | 25 | 89.3% | 22 | 88.0% | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% |
| MF | 18 | 17 | 94.4% | 16 | 94.1% | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% |
| S5 | 7 | 6 | 85.7% | 5 | 83.3% | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% |
| **Total** | **1,342** | **1,227** | **91.4%** | **1,153** | **94.0%** | **35** | **2.9%** | **31** | **2.5%** | **101** | **8.2%** | **29** | **2.4%** |

AdminRX Analytics by Unit.

**Appendix D. Pharmacy Robotic Dispensing Survey.**

## Pharmacy Survey – Robotic Dispensing

Thank you for taking the time to complete this anonymous survey. We are interested in your responses about how the McKesson Robot-RX® system has impacted your delivery of patient care. By completing and submitting this evaluation form, you are consenting to take part in this study.
Instructions:
Please read each item carefully and rate the technology provided to you for this research study. If you need assistance completing this form, please contact John Hargreaves at (814) 269-5277.

**1. From your perspective, the McKesson Robot-RX® system has increased filling accuracy.**

◯ Strongly Agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Strongly Disagree

**2. From your perspective, the McKesson Robot-RX® system has significantly reduced missing medications.**

◯ Strongly Agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Strongly Disagree

**3. From your perspective, the McKesson Robot-RX® system has minimized issues with expired medications.**

◯ Strongly Agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Strongly Disagree

**4. From your perspective, the McKesson Robot-RX® system has significantly reduced the amount of checking time needed and medications are delivered to the floor quicker.**

◯ Strongly Agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Strongly Disagree

**5. How would you rate the Robot-Rx® system and associated components with respect to ease of use.**

◯ Very Easy ◯ Easy ◯ Neutral ◯ Difficult ◯ Very Difficult

**6. What percentage of the hospital's medications has been impacted by this system?**

◯ 100% ◯ 95-99% ◯ 90-94% ◯ 85-89% ◯ 80-84% ◯ <80% ◯ Not Sure

**7. You have been able to spend more time on clinical activities since the new system was implemented?**

◯ True ◯ False ◯ N/A

**8. If true, how many minutes per day?**

## Pharmacy Survey – Robotic Dispensing

**9. From your perspective, the McKesson Robot-RX® system has improved patient safety through a reduction in "near misses" and reportable medication errors.**

◯ Strongly Agree ◯ Agree ◯ Neutral ◯ Disagree ◯ Strongly Disagree

**10. Would you recommend this system to other hospitals?**

◯ Yes ◯ No ◯ Not Sure

**11. How long have you been a pharmacist or technician?**

◯ 0-5 Years ◯ 6-10 Years ◯ 11-15 Years ◯ 16-20 Years ◯ 20+ Years

**12. Please provide additional comments on this topic as necessary.**

**Appendix E. Nurses' Survey - Medication Administration System Survey.**

# Medication Administration System Survey – Nurses' Assessment Survey

## 1. Welcome

Thank you for participating in the Medication Administration System Survey –

Nurses' Assessment Survey (MAS-NAS) project.

Completing this form indicates you recognize that this is a research project. As a token of our appreciation, you will receive a $20.00 incentive from Sheetz when you have completed the survey. After completion, please call 814-269-5277 to arrange receipt and please have your "SUM" available. We reserve the right to withhold incentive for any reason related but not limited to that which compromises the survey intent, data validity, completion compliance, or respondent eligibility.

If you previously completed a MAS-NAS, please complete this survey so we can learn how barcode/eMAR has changed how you administer medications. We will compare nurses' responses on this MAS-NAS with previous surveys completed in 2012 to learn the impact of converting to barcode/eMAR on CHS nurses.

If this is your first MAS-NAS, we would like to learn your beliefs about the system.

Please create a five digit confidential identifier called SUM. This allows us to maintain your privacy while being able to compare surveys taken at different times. Even if this is your first survey, please compute your SUM. We ask you to calculate the following number and place it in the space provided. The number is the SUM of the last five digits of your social security number added to the last five digits of your home telephone number. If your telephone number changed, please use the number you previously used. Only the SUM of those two numbers should be recorded on the first page of the survey. If your sum has more than five digits, record only the last five. See example below:

Last five social security numbers = 52346
+
Last five home telephone numbers = 58721
SUM = 111067

ENTER 11067 (last five)

After calculating your SUM, please:
Add your SUM on the next page and complete the survey.

Thank you for your participation in this important project!

## 2. Introduction

***1. SUM:**

***2. Date of completing the survey:**

## Medication Administration System Survey – Nurses' Assessment Survey

***3. Nursing Unit:**

- ◯ Meyersdale Medical Center
- ◯ Miners Medical Center
- ◯ Ashman 6 ICU
- ◯ Ashman 7
- ◯ Ashman 8
- ◯ Ashman 9
- ◯ Ashman 10
- ◯ Rose 6 ICU
- ◯ Rose 7 CICU
- ◯ Rose 7 Telemetry
- ◯ Rose 8
- ◯ Rose 8 PCU
- ◯ Rose 9
- ◯ Rose 10
- ◯ E4
- ◯ E6
- ◯ GS 4
- ◯ GS 5
- ◯ GS 6
- ◯ ASU
- ◯ PACU
- ◯ Crichton Rehab
- ◯ Med Surg 7
- ◯ RICN
- ◯ Maternity
- ◯ Pediatrics
- ◯ Geropysch
- ◯ Aloysia Hall
- ◯ Behavioral Health
- ◯ School of Nursing
- ◯ Float
- ◯ TCU

# Medication Administration System Survey – Nurses' Assessment Survey

Other (please specify)

The following statements describe experiences and beliefs about the current medication administration system you use. By current medication administration system, we mean the institutional structures and operational policies that direct and support the process and procedures of delivering/administering pharmaceutical products to patients. This includes all activities from medication ordering to dispensing to administration and documentation as well as all supplies and technologies associated with the current medication system, such as computer terminals, medication storage units, drug/drug interaction information, patient education sheets, infusion pumps, tubings, syringes, etc that are required in the process of getting medications to patients.
Completing this survey should take about 10 minutes.
By completing this survey, you are indicating consent to participate in this evaluation.
Please read each statement and circle the number that best expresses your own experiences and beliefs.
There are no right or wrong answers.
Do not write your name on the survey.
Please indicate the degree to which you agree or disagree with each item by using the following RATING SCALE.

Choose:
1 if you strongly agree with the statement.
2 if you moderately agree with the statement.
3 if you slightly agree with the statement.
4 if you slightly disagree with the statement.
5 if you moderately disagree with the statement.
6 if you strongly disagree with the statement.
NA if the statement does not apply to you.

Example: The current medication administration system provides adequate information about possible mediation side effects.
Answer: If you believe that you always have access to the type and amount of information you need to be able to assess for and manage potential side effects of medications you administer, you should circle 1 because that statement best expresses your belief.

## 3. Questions

**4. Because of information available through the current medication administration system I know both the intended actions and side effects of medications I administer.**

| ◯ 1 | ◯ 2 | ◯ 3 | ◯ 4 | ◯ 5 | ◯ 6 | ◯ NA |
|---|---|---|---|---|---|---|
| Strongly Agree | Moderately Agree | Slightly Agree | Slightly Disagree | Moderately Disagree | Strongly Disagree | Not Applicable |

**5. I find the drug alert feature (drug/drug or drug/food interaction) of the current medication administration system helpful.**

| ◯ 1 | ◯ 2 | ◯ 3 | ◯ 4 | ◯ 5 | ◯ 6 | ◯ NA |
|---|---|---|---|---|---|---|
| Strongly Agree | Moderately Agree | Slightly Agree | Slightly Disagree | Moderately Disagree | Strongly Disagree | Not Applicable |

## Medication Administration System Survey – Nurses' Assessment Survey

**6. The current medication administration system makes it easy to check active medication orders before administering medications.**

| ◯ 1 | ◯ 2 | ◯ 3 | ◯ 4 | ◯ 5 | ◯ 6 | ◯ NA |
|---|---|---|---|---|---|---|
| Strongly Agree | Moderately Agree | Slightly Agree | Slightly Disagree | Moderately Disagree | Strongly Disagree | Not Applicable |

**7. The current medication administration system provides me with information to know that a medication order has been checked by a pharmacist before I administer the medication.**

| ◯ 1 | ◯ 2 | ◯ 3 | ◯ 4 | ◯ 5 | ◯ 6 | ◯ NA |
|---|---|---|---|---|---|---|
| Strongly Agree | Moderately Agree | Slightly Agree | Slightly Disagree | Moderately Disagree | Strongly Disagree | Not Applicable |

**8. The current medication administration system promotes 2-way communication between clinicians (MD, Pharmacist, RN) about medication orders.**

| ◯ 1 | ◯ 2 | ◯ 3 | ◯ 4 | ◯ 5 | ◯ 6 | ◯ NA |
|---|---|---|---|---|---|---|
| Strongly Agree | Moderately Agree | Slightly Agree | Slightly Disagree | Moderately Disagree | Strongly Disagree | Not Applicable |

**4.**

**9. I have access to the systems that support medication administration (physician's orders, drug information) when I need them.**

| ◯ 1 | ◯ 2 | ◯ 3 | ◯ 4 | ◯ 5 | ◯ 6 | ◯ NA |
|---|---|---|---|---|---|---|
| Strongly Agree | Moderately Agree | Slightly Agree | Slightly Disagree | Moderately Disagree | Strongly Disagree | Not Applicable |

**10. The drug information available through the current medication administration system is easy to get when I need that information.**

| ◯ 1 | ◯ 2 | ◯ 3 | ◯ 4 | ◯ 5 | ◯ 6 | ◯ NA |
|---|---|---|---|---|---|---|
| Strongly Agree | Moderately Agree | Slightly Agree | Slightly Disagree | Moderately Disagree | Strongly Disagree | Not Applicable |

## Medication Administration System Survey – Nurses' Assessment Survey

**11. I know where all the medications I need are stored (either on the unit or if they need to be procured from the pharmacy).**

| ◯ 1 | ◯ 2 | ◯ 3 | ◯ 4 | ◯ 5 | ◯ 6 | ◯ NA |
|---|---|---|---|---|---|---|
| Strongly Agree | Moderately Agree | Slightly Agree | Slightly Disagree | Moderately Disagree | Strongly Disagree | Not Applicable |

**12. The current medication administration system helps me to be efficient at medication administration.**

| ◯ 1 | ◯ 2 | ◯ 3 | ◯ 4 | ◯ 5 | ◯ 6 | ◯ NA |
|---|---|---|---|---|---|---|
| Strongly Agree | Moderately Agree | Slightly Agree | Slightly Disagree | Moderately Disagree | Strongly Disagree | Not Applicable |

**13. The current medication administration system makes it easy to check that I am following the "5 rights" when I administer medications.**

| ◯ 1 | ◯ 2 | ◯ 3 | ◯ 4 | ◯ 5 | ◯ 6 | ◯ NA |
|---|---|---|---|---|---|---|
| Strongly Agree | Moderately Agree | Slightly Agree | Slightly Disagree | Moderately Disagree | Strongly Disagree | Not Applicable |

**14. The turnaround time for receiving medications needed "stat" or for patients newly admitted to the unit is adequate.**

| ◯ 1 | ◯ 2 | ◯ 3 | ◯ 4 | ◯ 5 | ◯ 6 | ◯ NA |
|---|---|---|---|---|---|---|
| Strongly Agree | Moderately Agree | Slightly Agree | Slightly Disagree | Moderately Disagree | Strongly Disagree | Not Applicable |

**15. The current medication administration system is effective in reducing and preventing medication errors.**

| ◯ 1 | ◯ 2 | ◯ 3 | ◯ 4 | ◯ 5 | ◯ 6 | ◯ NA |
|---|---|---|---|---|---|---|
| Strongly Agree | Moderately Agree | Slightly Agree | Slightly Disagree | Moderately Disagree | Strongly Disagree | Not Applicable |

**16. The current medication administration system is user-friendly to the nurses who administer medications.**

| ☐ 1 | ☐ 2 | ☐ 3 | ☐ 4 | ☐ 5 | ☐ 6 | ☐ NA |
|---|---|---|---|---|---|---|
| Strongly Agree | Moderately Agree | Slightly Agree | Slightly Disagree | Moderately Disagree | Strongly Disagree | Not Applicable |

## Medication Administration System Survey – Nurses' Assessment Survey

**17. The equipment and/or supplies needed to administer medications are readily available to me.**

| ◯ 1 | ◯ 2 | ◯ 3 | ◯ 4 | ◯ 5 | ◯ 6 | ◯ NA |
|---|---|---|---|---|---|---|
| Strongly Agree | Moderately Agree | Slightly Agree | Slightly Disagree | Moderately Disagree | Strongly Disagree | Not Applicable |

**18. Information available through the current medication administration system helps me to know what to do should my patient have any bad reactions from a medication.**

| ◯ 1 | ◯ 2 | ◯ 3 | ◯ 4 | ◯ 5 | ◯ 6 | ◯ NA |
|---|---|---|---|---|---|---|
| Strongly Agree | Moderately Agree | Slightly Agree | Slightly Disagree | Moderately Disagree | Strongly Disagree | Not Applicable |

**19. I have to keep stashes of medications to be sure I have medications I need when I need them.**

| ◯ 1 | ◯ 2 | ◯ 3 | ◯ 4 | ◯ 5 | ◯ 6 | ◯ NA |
|---|---|---|---|---|---|---|
| Strongly Agree | Moderately Agree | Slightly Agree | Slightly Disagree | Moderately Disagree | Strongly Disagree | Not Applicable |

### 5. Open-ended

**20. Please add any comments you wish about the current medication administration system and the degree to which components of the current system support your ability to administer medications safely and professionally.**

**21. If you could change one thing in the current medication administration system, what would it be?**

### 6. BCMA

**22. Did you work on an inpatient nursing unit at CHS before BCMA (Admin-Rx) was implemented?**

◯ Yes ◯ No

## Medication Administration System Survey – Nurses' Assessment Survey

**7.**

Comparing now (using barcode/eMAR) with the old system, please respond to the following 7 statements.

**23. It is easier to do all the checking steps needed during the medication administration process.**

◯ Strongly Agree ◯ Moderately Agree ◯ Slightly Agree ◯ Slightly Disagree ◯ Moderately Disagree ◯ Strongly Disagree ◯ Did not use old system

**24. This is a safer system for patients.**

◯ Strongly Agree ◯ Moderately Agree ◯ Slightly Agree ◯ Slightly Disagree ◯ Moderately Disagree ◯ Strongly Disagree ◯ Did not use old system

**25. With the new system, it is easier to access information I need to administer medications.**

◯ Strongly Agree ◯ Moderately Agree ◯ Slightly Agree ◯ Slightly Disagree ◯ Moderately Disagree ◯ Strongly Disagree ◯ Did not use old system

**26. I am more satisfied with this new medication administration system than with the previous one.**

◯ Strongly Agree ◯ Moderately Agree ◯ Slightly Agree ◯ Slightly Disagree ◯ Moderately Disagree ◯ Strongly Disagree ◯ Did not use old system

**27. I have more time to spend with patients.**

◯ Strongly Agree ◯ Moderately Agree ◯ Slightly Agree ◯ Slightly Disagree ◯ Moderately Disagree ◯ Strongly Disagree ◯ Did not use old system

**28. Barcode/eMAR has made the medication administration process more efficient for me.**

◯ Strongly Agree ◯ Moderately Agree ◯ Slightly Agree ◯ Slightly Disagree ◯ Moderately Disagree ◯ Strongly Disagree ◯ Did not use old system

## Medication Administration System Survey – Nurses' Assessment Survey

**29. Medications are more readily available when I need them for patients.**

- ◯ Strongly Agree
- ◯ Moderately Agree
- ◯ Slightly Agree
- ◯ Slightly Disagree
- ◯ Moderately Disagree
- ◯ Strongly Disagree
- ◯ Did not use old system

### 8. Closing

***30. Overall, how satisfied are you with the current medication administration system? Please select.**

◯ 1 - Completely Dissatisfied ◯ 2 ◯ 3 ◯ 4 ◯ 5 - Neither satisfied nor dissatisfied ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ 10 - Completely Satisfied

***31. How long have you been using the BCMA system (Admin-Rx) with patients?**

- ◯ Less than 1 month
- ◯ 1-3 months
- ◯ 4-6 months
- ◯ 7-9 months
- ◯ 10-12 months

Please provide the following information about yourself and your background.

**32. Gender:**

- ◯ Male
- ◯ Female

**33. Age:**

**34. Highest nursing degree:**

- ◯ LPN
- ◯ Diploma
- ◯ AS/AD
- ◯ BS/BSN
- ◯ MS/MSN

**35. Number of years employed as a nurse:**

***36. Number of years employed by Conemaugh:**

**37. Number of hours worked in a typical week:**

## Medication Administration System Survey – Nurses' Assessment Survey

**38. Typical shift rotation schedule:**

- ◯ All Shifts
- ◯ Evenings
- ◯ Nights
- ◯ Rotate D/E
- ◯ Rotate D/N
- ◯ All Days
- ◯ 7A-7P
- ◯ 7P-7A

**39. Typical weekly schedule:**

- ◯ mostly weekend/holiday
- ◯ mostly Monday-Friday
- ◯ rotate weekdays/weekends/holidays

***40. Current position:**

- ◯ staff/direct patient care (staff RN/NIC)
- ◯ leadership/management
- ◯ education
- ◯ Student

Other (please specify)

**41. Compared to your nursing peers, how do you rate your computer skills?**

- ◯ Above Average
- ◯ Average
- ◯ Below Average

**42. Do you use a computer at home?**

- ◯ Yes
- ◯ No

**43. How do your rate your skill at obtaining patient care information from the Conemaugh computer systems?**

- ◯ Excellent
- ◯ Good
- ◯ Fair
- ◯ Poor

**44. Did you ever use barcode/eMAR in another hospital before working at CHS?**

- ◯ Yes
- ◯ No

Copyright by Ann C. Hurley, Diane R. Lancaster, Judy Hayes, Anne Bane, Chantel Wilson Chase, 2003. Do not copy, circulate, or cite without written permission of the researchers.

**Appendix F. Nursing Student - Medication Administration System Survey.**

## Nursing Student BCMA

This survey is intended for nursing students enrolled in the Conemaugh School of Nursing. We are asking for your feedback regarding bar code medication administration (BCMA) (Admin Rx) at Conemaugh Memorial Medical Center. As a token of our appreciation, you will receive a $20.00 incentive from Crossroads café when you have completed the survey. After completion, please call 814-269-5232 to arrange receipt and please have your "CODE" available. We reserve the right to withhold incentive for any reason related but not limited to that which compromises the survey intent, data validity, completion compliance, or respondent eligibility. Thank you for your time and input.

***1. Please create a 7 character "CODE" using both numbers and letters. Enter here.**

***2. Please state your gender:**

◯ Male ◯ Female

***3. Please select your age:**

**Round your age to the nearest whole year.**

◯ 20 years or less ◯ 31 – 40 ◯ 51 – 60

◯ 21 – 30 ◯ 41 – 50 ◯ Greater than 61 years

***4. Today's date:**

***5. Current status:**

◯ 1st Year Student ◯ 2nd Year Student

***6. How often do you use the medication carts (blue Rubbermaid with drawers) on inpatient units?**

◯ Frequently ◯ Very Often ◯ Sometimes ◯ Not Very Often ◯ Never

***7. Do you have access to medication carts (blue Rubbermaid with drawers) when you need them for training on the floor?**

◯ Frequently ◯ Very Often ◯ Sometimes ◯ Not Very Often ◯ Never

***8. The current medication administration system helps me to be efficient at medication administration.**

◯ Strongly Agree ◯ Slightly Disagree

◯ Moderately Agree ◯ Moderately Disagree

◯ Slightly Agree ◯ Strongly Disagree

Page 1

## Nursing Student BCMA

***9. The current medication administration system makes it easy to check that I am following the "5 rights" when I administer medications.**

- ◯ Strongly Agree
- ◯ Moderately Agree
- ◯ Slightly Agree
- ◯ Slightly Disagree
- ◯ Moderately Disagree
- ◯ Strongly Disagree

***10. The current medication administration system is effective in reducing and preventing medication errors.**

- ◯ Strongly Agree
- ◯ Moderately Agree
- ◯ Slightly Agree
- ◯ Slightly Disagree
- ◯ Moderately Disagree
- ◯ Strongly Disagree

***11. Overall, how satisfied are you with the current medication administration system?**

◯ 0 - Completely Dissatisfied ◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 - Neutral ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ 10 - Completely Satisfied

***12. Do you have previous BCMA experience outside of Conemaugh?**

- ◯ Yes
- ◯ No

**13. Please add any comments you wish about the current medication administration system.**

Thank you for your time and input! Have a good day.

**Appendix G. Physician Medication Administration Survey.**

## Physician - BCMA and eMAR System

Thank you for taking the time to complete this anonymous survey. We are interested in your responses about how the new Bar Code Medication Administration (BCMA) and electronic Medication Administration Record (eMAR) system has impacted your delivery of patient care. By completing and submitting this survey, you are consenting to take part in this study.

Instructions:

Please read each item carefully and rate the technology provided to you for this research study. If you need assistance completing this survey, please contact John Hargreaves at (814) 269-5277.

**1. How often do you access the electronic medication administration record (eMAR) module available through Care Portal?**

- ◯ Frequently
- ◯ Sometimes
- ◯ Seldom
- ◯ Never

**2. The new eMAR module has improved my decision-making and efficiency because I can now electronically access if/when ordered medications were administered from various locations.**

- ◯ Strongly Agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly Disagree

**3. Adverse drug events have reduced because of the bar coding technology and additional nursing safeguard warnings/alerts in place to reduce medication errors.**

- ◯ Strongly Agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly Disagree
- ◯ Don't Know

## Physician - BCMA and eMAR System

**4. The new Bar Code Administration Administration (BCMA) system and Care Portal eMAR module have improved physician communication with pharmacy and nursing.**

- ◯ Yes
- ◯ No
- ◯ Not Sure

**5. I would recommend our new BCMA system and Care Portal eMAR module to other acute care hospitals.**

- ◯ Strongly Agree
- ◯ Agree
- ◯ Neutral
- ◯ Disagree
- ◯ Strongly Disagree

**6. How many years have you been a practicing physician or physician assistant?**

- ◯ Not Applicable
- ◯ 0-5 Years
- ◯ 6-10 Years
- ◯ 11-15 Years
- ◯ 16-20 Years
- ◯ 20+ Years

**7. Please select your affiliation.**

- ◯ Physician - Conemaugh Physician Group
- ◯ Physician - Hospitalist
- ◯ Physician - Independent
- ◯ Physician Assistant
- ◯ Resident

**8. Do you have BCMA and eMAR experience outside of Conemaugh?**

- ◯ Yes
- ◯ No

**9. Please provide comments on this topic as necessary.**

**Appendix H. Selected Software Development Activities, including vendors NCG and CGI Federal, Inc.**

## *2010*

1. A "Kick Off Meeting" was held with TATRC representatives on October 19, 2010 to review project deliverables. A decision was made to proceed using the CONNECT version 3.1 architecture for health information exchange (HIE) in a production environment.
2. Adrian Anderson (NHIN operations team) provided the NHIN conformance testing packet on November 24, 2010 to Conemaugh. These tests needed executed during the NHIN on-boarding process.
3. The CONNECT v3.1 document assembler plugin has been "patched" to create a C32 document. As such, the code was shared with the TATRC Advanced Concepts Team (ACT) for review and use on December 17, 2010. Conemaugh also provided the code to the Federal Health Architecture (FHA) CONNECT team for incorporation into their baseline.†
4. Conemaugh led a MIDHT demo at the HIMSS Interoperability Showcase™ in Orlando, FL in February 2011.

## *2011*

1. Implemented document assembler changes for onset date within Allergies and Problems†
   - Updated Document Assembler to populate the <text> field in the C32 with the parsed <text> field from the CareRecord for Allergies and Problems (parsed the date information from the text field).
   - Updated the Conemaugh style sheet to display the <text> field if the effectiveTime field was not populated.
2. Resolved the persistence issues within the patient consent module v3.1†
   - Opt-in/Opt-out consumer consent choices are now persisted.
3. Created WSDL for Emergency Room Discharge Summary†
   - The CAL WSDL was updated and provided to Conemaugh as part of the overarching Emergency Room (ER) Discharge Summary tasking.
4. CONNECTUniversalClientGUI SAML errors†
   - This update addresses the issue that is encountered when the user tries to search for a patient from the mpi.xml file using the CONNECTUniversalClientGUI application. Specifically, adding the appropriate xml files to the src\main\java\META-INF folder and updating the wsit-client.xml file to reflect that the missing files were added solves this issue.
5. Multiple items returned from Initiate†
   - Modified the Initiate Connector to parse the Initiate response in the event that multiple patients are returned with the same EID. Response returned contains the most updated patient entry per EID.
6. Updates to CONNECT Universal Client GUI†
   - This update allows the user to choose targeted gateways via a combo box that appears under both the patient discovery and document query tabs. This update also dynamically chooses a style sheet to render a document against, based on the OID of the responding gateway.

† Completed by Northrop Grumman

7. Implemented Spring Injection points in CONNECT v3.1 framework for Patient Discovery†
   - Spring Injection points now allow for one of four selectable implementations for every service in CONNECT v3.1 framework for Patient Discovery
8. Patient Discovery - Responding side to Initiate†
   - Allows a patient discovery request from a remote gateway to pass through the CHS Gateway and adapter, then on to Initiate, where a patient lookup is performed, and the results are passed along to the requestor. This external search allows at most one patient, and a high threshold (minScore) to be sent to Initiate. Also, internal patient search has been enhanced to use the same flow through, with different rules (allows multiple returns, sets different min score (lower threshold) to Initiate)
9. Patient Discovery - Initiating side to Initiate†
   - Changes were made to the CONNECTUniversalClientGUI in order to facilitate the building of a Patient Discovery Request that can be sent to all configured gateways or to targeted gateways. In support of the target gateway functionality, a textbox was added under the Patient Discovery tab. This textbox allows users to input the OIDs of target communities. In addition to the updates that were made to the GUI code, updates were also made to the interactionId value that is contained within the CHSCoreLib and CONNECTCoreLib projects. The change updates the value to reflect the actual type (PRPA_IN201305UV02 instead of PRPA_IN201305UV) of the request that is being sent out.
10. Modified Patient Discovery Response to be compliant with Patient Discovery Specification†
    - This modification enhanced the response created by the Initiate Connector by making it Patient Discovery schema compliant
11. Added functionality to the Document Assembler to allow for handling of multiple Emergency Room Discharge Summaries (C62's)†
    - Enhanced the Document Assembler to be able to assemble (query and retrieve) multiple C62 documents, for a single patient.
12. Updated CONNECT Universal Client GUI Inbox to allow for display C62's†
    - The existing VLER Inbox code has been incorporated into the CONNECTUniversalClientGUI so that C62documents can be rendered.
13. C62 documents are not returned during a query if a C32 document is requested (based on class code)†
    - Code modified to enforce class code sent in request for all applicable documents.
14. Investigated enforcement of Opt-In/Opt-Out for Patient Consent†
    - When Patient Consent is configured to support the Opt-In/Opt-Out enforcement, this code will block all requests for data for any patient who has "Opted Out" or who has not made an Opt-In or Opt-Out selection. Data will be returned only for those patients who have made an Opt-In choice and had their choice stored in the document database in their Consumer Preferences Profile (CPP) document.
15. Demonstrated the ability to secure the MIDHT GUI's using OpenSSO in conjunction with OpenDS and document the installation procedures.†
16. On October 21, 2011, Allen Barger and Zeke Bravo participated in a demonstration of the Consumer Preferences Profile (CPP) GUI in which the opt-in and opt-out capabilities were demonstrated.†

† Completed by Northrop Grumman

***2012***

1. Changes were made by Conemaugh developers to the FindDocumentWithContent endpoint in order to add inpatient discharge summaries from three Conemaugh hospitals. VA was able to successfully query/retrieve a discharge summary on March 20, 2012.
2. In order to spur adoption of the NwHIN service by Conemaugh providers, technical teams have integrated the CONNECT UniversalClientGUI with the existing McKesson Care Portal. A new tab has been created and enrolled users will be able to access NwHIN data from an application that is used heavily on a daily basis. Context sharing has been implemented so the provider does not have to duplicate the patient search.
3. Integration and testing of production MPI and clinical systems via CAL occurred during the month of April 2012. Issues identified during testing were quickly resolved by the Conemaugh development team. Project team confirmed that all C32 data (problems, allergies, medications) is active to the patient and removed the default order date for "recorded" medications.
4. Conemaugh decided to add radiology reports (C62) from various hospital facilities to the production CAL service. Development work was completed on August 10, 2012, which included all radiology modalities (e.g. x-ray, CT, etc.) from the McKesson Horizon Patient Folder system. Consequently, an update was provided to the VA team and they quickly confirmed successful receipt of the said data.
5. Provided the Conemaugh technical team with instructions on how to implement 2-way SSL on Apache Tomcat and Microsoft IIS application servers.[†]
6. Complied with the VA's User acceptance Testing (UAT) by implementing and testing OID and URLs on the MIDHT production (VA testing) server.†
7. Conemaugh testing of medications data by providing log file snippets that contain a response from the Common Access Layer (CAL) medications endpoint.†
8. Used the Lantana testing tool to validate the structure of Conemaugh's Radiology Studies documents.†
9. Modified the C62 document builder code to build Radiology Studies documents from information provided by Conemaugh's CAL web service interface.†

***Donated the MIDHT CONNECT Universal Client GUI code to FHA†:***

- Created a virtual machine, running CONNECT v3.3.1, that can be used to test MIDHT code donations
- Prepared a Release Notes document for the CONNECT UC GUI code donation
- Upgraded the MIDHT CONNECT UC GUI to work with CONNECT v3.3.1
- Staged, committed and pushed code changes to the MIDHT Fork in GitHub
- Submitted a Pull Request from within GitHub
- Updated the TATRC Subversion repository with the revised GUI code
- Installed the CONNECT formatting templates for the NetBeans IDE

***Donated the MIDHT Common Access Layer (CAL) code to FHA†:***

- Cleaned up the AdapterCommonDataLayerEJB project by removing all of the deprecated files and "dead" code

[†] Completed by Northrop Grumman

- Prepared release notes, change list and install instructions documentation
- Upgraded the AdapterCommonDataLayerEJB project to work with CONNECT v3.3.1
- Staged, committed and pushed the code changes to the MIDHT Fork in GitHub
- Submitted a Pull Request to the CONNECT 3.3_integration branch
- Updated the TATRC Subversion repository with the revised code
- Installed and applied the CONNECT formatting templates for the NetBeans IDE
- Created a SoapUI project that can be used to test the CAL donation
- Removed all Conemaugh-specific identifiers from the donated code and configuration files.

***2013***

1. Modified the VA style sheet so that the date values in the Lab Results section are formatted and the header of each C32 section contains information about the patient (name, date of birth).
2. Appended "(INCLUDES LAB RESULTS)" to the end of the "34133-9 Summarization of Episode Note" entry in the CONNECT Universal Client GUI's *Select Document Types* drop-down box.
3. Made the following changes in production to the Medications section of the Conemaugh C32 document per request from VA:
   - Populated the substanceAdministration text tags with only the medication Sig value
   - Put the section text <content> tags in the same order as the corresponding SubstanceAdministration entries
   - Changed the ID attribute of each section <content> tag to be the medication Sig value instead of the name of the medication
4. Created user accounts in OpenDS and updated passwords as requested.
5. When requested, queried the MIDHT Audit Repository to confirm the Retrieve Document actions of certain VA users.
   - In response to the Healtheway eHealth Exchange support staff assuming administrative control for the UDDI domain registrar services, connectivity from the production Conemaugh gateway to the production eHealth Exchange UDDI was tested on July 8, 2013.
6. Patient consent issue
   - Patient consent documents were not being saved to the document repository because of a bug in CONNECT, which used an inappropriate method for assigning primary keys. The bug fix was developed, deployed, and verified with Conemaugh, and then applied to the CONNECT trunk.

***TATRC Partners and Open Source Community Outreach***

- NGC became a regular participant in the eHealth Exchange Spec Factory all-hands weekly teleconference.
- COGON Systems reached out to Allen Barger for help with validating the C62 document that they had been sending to the VA. Allen helped COGON validate their C62 document by performing the following actions:
  - Compared the COGON C62 document to a valid Conemaugh C62 document and suggested revisions
  - Loaded the COGON C62 document into the CAL emulator, and then rendered it using the CONNECT Universal Client GUI.

- On July 1, 2013, Allen Barger met with staff members from Regenstrief and provided them with guidance and lessons learned regarding C62 document development.

***Transition to CONNECT v3.3.1.3***

- Evaluated versions of OpenDS that are suitable for deployment with the Java install that is required by CONNECT v3.3.1.3.
- Updated the MIDHT code base to work with the CONNECT v.3.3.1.3 Core Libraries.
- Provided TATRC the CONNECTUniversalClientGUI binaries for use with CONNECT v3.3.1.3
- Created and deployed an updated Initiate adapter for use with CONNECT v3.3. The updated adapter eliminates an extra web service call and facilitates the use of the CONNECT build script to compile the adapter's code.
- Updated the AdpaterCommonDataLayerEJB, AdapterDocumentAssemblyProxyEJB, DocumentAssemblyManagerEJB, DocumentManagerEJB, NHINAdapterServicesEJB, and TemplateManagerEJB projects to accommodate the CONNECTCoreLib changes in CONNECT v3.3.1.3.
- Resolved the CONNECT Universal Client GUI issue that caused patient id's to be persisted across GUI sessions and included in the SAML header of future transactions.
- Sample C32 and C62 documents were produced from the transitioned MIDHT code and sent to Conemaugh for review.
- The CONNECT v3.3.1.3 Entity Doc Query, Adapter Doc Query, and NwHIN Doc Query requests and responses were compared to their CONNECT v3.1 counterparts.
- The CONNECT v3.3.1.3 C32 and C62 documents were compared to their CONNECT v3.1 counterparts.
- The CONNECT v3.3.1.3 document repository, audit repository, and patient correlation tables were compared to their CONNECT v3.1 counterparts.
- A CONNECT bug may be responsible for wrongly populating the Issuer and Issuer Format SAML Assertion values in the Audit Log and Adapter Document Query web service requests.
- Work was completed on creating a document that outlines how to install and configure the MIDHT code stack, built from CONNECT v3.3.1.3, on a Windows-based server.
- The following changes were made to the MIDHT CONNECT v3.3.1.3 code base:
- Properly formatted the Date of Birth (DOB) and telephone number values in the Patient Discovery request
- Added an "XDSDocumentEntryType" slot, used to request both stable and on-demand documents from eHealth Exchange participants, to the Document Query request
- Changed the value of the "returnComposedObjects" attribute, located in the Document Query request, from "false" to "true"
- Changed the Issuer SAML header value to be compliant with the NwHIN Authorization Framework and Oasis SAML specifications.
- Delivered a document to Conemaugh that outlines how to install and configure the MIDHT code stack, built from CONNECT v3.3.1.3, on a Windows-based server.
- The following changes were made to the MIDHT CONNECT v3.3.1.3 code base:
    - Set the Initiate min score to 99 for both internal and external patient lookups
    - Prevented the CONNECT Universal Client GUI from caching the internal Initiate min score after a patient lookup is performed in the GUI

    - For every MIDHT document that is saved to the document repository, populate the document's AvailabilityStatus repository field with "Available" instead of "Active"
    - For DQ requests that originate from the CONNECT Universal Client GUI, include a $XDSDocumentEntryType slot in the request if the targeted community supports the 2011 eHealth Exchange specifications.
- Enabled complete builds of the CONNECT code stack by updating the AdapterFrameworkIntTest project to work with architectural changes that were made to the Dynamic Document Assembler code
- Increased the Document Query web service Proxy timeout threshold.
- The migration of the CONNECT v3.3.1.3 MIDHT code base from the MIDHT-PREPROD33 server to the MIDHT-GOLIVE server was completed on September 19, 2013.

***VA Partner and eHealth Exchange Testing***

- On November 13, 2012, VA test cases were executed to monitor C32 changes that were made in support of VA's Adapter Maintenance Release 5.0.1. During the testing process, several Conemaugh initiated Patient Discovery, Document Query and Document Retrieve requests were sent to the VA test system and the returned responses were examined for accuracy.
- Northrop Grumman examined the VA C32 module content, which was produced during Adapter 5.0.1 validation testing, for accuracy and reported the findings to Conemaugh.
- The DIL certificates were successfully retrieved from Aegis and installed on the MIDHT-PREPROD33 server.
- On July 31, 2013, Allen Barger attended the eHealth Exchange Participant Testing Webinar.
- The uddiConnectionInfo_CONNECT33_41.xml file, which is used to direct the CHS gateway to the DIL endpoints, was successfully installed on the MIDHT-PREPROD33 server.
- At the request of the VA, Document Query tests were conducted for test patient NWHINONE on July 8, 15, and 17, 2013. The test results were extracted from Conemaugh's server log and sent to the VA for review.
- Helped determine if a NullPointerException, which prevented the DIL from sending requests to the Conemaugh test gateway, was originating from the DIL or Conemaugh's gateway.
- Northrop Grumman helped Conemaugh interpret a DIL error message regarding a missing patient id, and determined that a non-breaking space appended to the end of the patient id was the cause of the error.
- After eHealth Exchange validation testing concluded, the certificates, domain.xml file, and uddiConnectionInfo.xml file on the MIDHT-PREPROD33 server were configured for validation testing with the VA.
- On September 11-12, 2013, Allen Barger participated in the validation testing sessions that took place between Conemaugh and the VA.

***Lab Result Integration***

- Using sample messages provided by Conemaugh, NG successfully parsed HL7 v2.2 Lab Result messages using the open-source HL7 Application Programming Interface (HAPI) library to HLV v3.
- Assisted Conemaugh with identifying the data objects that comprise a HL7 v2.2 message.

- Coding efforts have produced a C32 document containing a Lab Results section that is populated with static Laboratory Observation data. As changes are made to the Lab Results section of the C32 document, the document's adherence to the CDA/CCD-based specifications are routinely validated using the NIST testing web site.
- The Document Assembler code was successfully modified to accommodate the parsing and interpretation of messages containing multiple Lab Orders and multiple Lab Results (for a given Lab Order).
- The CHS style sheet was augmented with a Lab Results section, which contains a Date/Time field, a Result Type field, a Result Value field, a Reference Range field, an Interpretation field, a Result Status field, and a Source field.
- Code was implemented to allow the represented organization for each Lab result to dynamically change based on the hospital code value in the MSH section of the ORU_R01 message.

***2014 – CGI Federal, Inc.***

1. Preproduction certificate update – The eHealth Exchange validation certificate in the pre-production environment expired in January; worked with John to update that certificate.
   - Unfortunately the standard process for importing the signed eHealth Exchange certificate back into the originating keystore no longer works. The suspicion is that some process or technology on the entrust site has silently changed, it is common knowledge that some Java Development Kit (JDK) implementations create slightly differently formatted PEM and DER encoded which the Oracle JDK has trouble with.
   - Unfortunately it's difficult to confirm this as the culprit without input on the technology used on the Entrust side. After many hours looking at this issue and with folks from MiHIN (facing a similar issue) we were able to create a workaround.
   - The work around involves converting the original keystore to the PKCS12 format and then importing the signed certificate with another tool called OpenSSL, then converting the certificate back to JKS.
2. Preproduction certificate resolution – There was a request by Healtheway to Entrust to modify the algorithm for the eHealth Exchange security certs. Creating an interoperability issue between older eHealth Exchange certificates and the newer ones. There was a significant amount of research performed and working with multiple organizations besides Conemaugh to isolate and resolve the issue.
   - Though Healtheway stands by their decision that it was a good and necessary certificate upgrade, Healtheway representatives have finally agreed with the findings of the support team and are working with Entrust for a better process when making these types of upgrades and transitions in the future.
   - As part of responding to the larger impacts of CONNECT implementers in the eHealth Exchange community the support team wrote up and contributed documentation to 1) Detail how to update a new root certificate from the eHealth Exchange and 2) Key troubleshooting steps for chain of trust issues.
3. Researched and developed a fix for an issue with test UDDI results issue where the maximum number of entries of 100 was hardcoded in the code. Tested and deployed the configurable return value for UDDI results into the Conemaugh environments.
4. Attended meetings and worked on an approach to on-demand document improvements for Conemaugh. The approach will involve a Document Assembly Manager to incorporate the three separate lab messages into an aggregated single synchronous message and pass it to the

Common Access Layer.

5. Added lab capabilities to the Document Assembly Manager, leveraging the code developed for 3.1 and merging it with minor modifications for 3.3.1.3.
   - Built and deployed Conemaugh lab reporting modifications from MIDHT_PHASE3 repository
   - Tested lab reporting modifications and found missing functionality added in CONNECT 3.3 (because MIDHT_PHASE3 was based on CONNECT 3.1), made necessary updates
   - Merged lab reporting modifications into CONNECT 3.3 and built and deployed
   - Testing/troubleshooting is on-going, continuing to coordinate with Conemaugh resources
   - CMIDHT-6 Updated CommonDataLayer Adapter for querying lab results
   - CMIDHT-7 Updated Lab Response Builder to pull information from correct message type
   - CMIDHT-8 Updated information source of CDA header for correct hospital information
   - CMIDHT-9 Modified LabResponseBuilder and retrieve Lab Results for Patient NWHINTWO NWHINZZZTESTPATIENT
   - Supported securing Conemaugh related services, an issue with client-auth in production; ultimate fix was not small and not non-invasive
   - Merged code received from Conemaugh into 3.3.1.3 codebase
   - Fixed build issues due to integrated code in local 3.3.1.3 to proceed
   - Wrote unit tests to validate the flow of LabModule work
   - Added interface to call LabModule in CAL
   - Made required code changes in the WSDL provided to the CAL Service
   - Made required code changes to accommodate the Schema for the same service
   - Modified the code to get the Response (Response as String) as per modified WSDL and Schema
   - Cleanup of previous contractor work to accommodate receiving Response of type ORF_R04 (was ORU_R01)
   - Performed additional analysis on message variations between ORF_R04 and ORU_R01 to account for and properly read the new message type
6. Work also continued on the C32 clinical document builder:
   - CMIDHT-10 – Researched HL7 lab results and introduced filtering logic to filter out specific text to provide the correct display of results and remove unwanted information.
   - CMIDHT-11 – Corrected values to meet the VA style sheet expectations. Concatenated multiple OBXs with the same ID and mirrored how the VA was handling comments.
   - CMIDHT-13 – Researched issues and introduced additional search criteria for “Reference range” and “Units” in the OBX text block. The new logic properly filter and displays the results in the F observation.
   - CMIDHT-14 – Researched results and added additional filtering logic to properly support certain orders such as a blood bank order which appears as multiple OBXs.
   - CMIDHT-15 - Updated the adapter to change the lab result type to populate in the display name not the reference value to comply with the VA style sheet.
   - CMIDHT-16 – Continued to refine the adapter to comply with the VA style sheet by adding more logic to handle variations in the lab result messages, updated the XSL to pull result type for display from display name.
   - CMIDHT-18 – Inconsistencies and display issues with lab results in VA VistA.
     - Performed research and developed two options, presented these to Conemaugh for review.
     - Received guidance to proceed with the second option detailed in the JIRA ticket.
     - Developed, tested and implemented the solution, was verified with the VA.

- CMIDHT-20 – Add OBX information to comment field in C32 instead of individual result.
    - Researched supporting specifications and reviewed current coding to see how this would mesh with current customized adapter logic.
    - Discussed via email with Conemaugh received approval with the following logic contained in the JIRA ticket comments (August 28, 2014).

7. Provided additional research and guidance related to HL7 lab messages and the best way to handle the variances and discern what the VA might be expecting based on the labs result messages being supplied
8. Completed support for Conemaugh testing with the VA (In their Production/ Live data testing) o Closed the ticket used for monitoring and tracking the testing work CMIDHT-12, all open issues are resolved, lab result variances are accounted for and style-sheet inconsistencies have been corrected
    - Worked with the VA team to resolve an endpoint issue with the their testing, final result seemed to indicate it was an issue on the VA side which was resolved and testing continued

    - CMIDHT-27 – Integrate CONNECT Lab Module Adapter Implementation in Conemaugh Production Server
        - Installed Adapter Implementation of Lab Module on Conemaugh Production server and support testing in Production
        - Moved necessary jars and configuration files that are added/updated as part of Lab integration in Adapter Implementation
        - Supported testing on Production server
    - CMIDHT-29– Completed endpoint configuration verification for the Test environment ensuring it will utilize 2011 versions for VA testing. Verification included the following service endpoints PD, QD and RD.
        - The 2010 endpoints specified in internalConnectionInfo.xml would override the 2011 endpoints of uddiConnectionInfo.xml. The 2010 endpoints in internalConnectionInfo.xml were removed as part of this ticket; hence the Test CONNECT gateway will be using uddiConnectionInfo.xml for lookup pulling in the 2011 endpoints contained in the Healtheway Test UDDI.
9. Coordinated with the eHealth Exchange personnel on securing and validating the new EHEX Entrust Production Certificate.

***2015 – CGI Federal, Inc.***

1. CMIDHT-31 – In order to support the VA's January 11th transition to 2011 NwHIN specifications in production the productionInternalConnectionInfo file was updated to remove 2010 endpoints to support this move by the VA.
    - The file was updated and testing conducted to ensure proper function. Also verified in coordination with Conemaugh and VA teams.
2. CMIDHT-32 – Begin to perform the research to support the VA's move to supporting C-CDA documents. There was a concern the current stylesheet will not support the change in document types.
    - Some initial research was performed but for efficiency the decision was made to request a fully populated sample from the VA to ensure all sections are covered.
    - Conemaugh plans to retrieve CCDA documents from VA going forward. VA will support both C32s and CCDA, and will have a system in place to provide documents

(types) based on the remote community. Style-sheet needs to be updated to accommodate the VA CCDA.

- Created a list of the items and updates the style-sheet needs to be updated with in order to accommodate the VA CCDA.
- Made the necessary changes required to support the style-sheet to display C-CDA documents.
- Verified with Conemaugh that testing will need to wait until the “PurposeOfUse” is changed back once testing of this data element is complete.
- Reverted back to the “purpose of use” to “treatment” and began testing the C-CDA stylesheet changes.
- Researched and resolved an issue with the XSL and IE8, issue was a discrepancy that not all browsers were being applied.
- Began making sure NWHINFIVE and VA SQA3 are ready for testing, understanding the VA stylesheet incremental changes or improvements.
- Researched why not all sections are showing in the new style sheet.
- Determined along with Conemaugh the best timing and rollout strategy for new stylesheet.

3. CMIDHT-33 – Conemaugh is an "unknown" sender in production VAP. Initial research indicated that the VA was looking for a couple of the assertion values (namely Organization Id and Organization) are not being populated in requests from Conemaugh to VA. Ideally these values are sent through the entity interface assertion element.
    - This issue was caused as the VA upgraded to CONNECT 4.2.2.2 with CXF as the web services server and Conemaugh is on CONNECT 3.3.1.3 using Metro as the web services server.
    - The SAML Assertion Organization Id is prepended with “urn:oid: “ in the test environment and successfully tested sending a PD,DQ and DR for the “NWHINONE” patient and provided log snippets to illustrate compliance.
4. CONNECT Timeout Settings Confirmation - Verified and reported back that the CONNECT services were set to 20 minutes.
5. Testing Purpose of Use Elements with the VA - The VA requested conducting a test with them against their test environments using the data element ‘emergency’ for the Purpose of Use.
    - The values were modified for purposeOfUse code and display Name to “Emergency” in Test environment. Restarted the gateway and self-query tests were performed and verified the purposeOfUse code and displayName.
    - Conemaugh was notified the gateway was ready for testing with the VA. Tests were run with the VA and awaited results.
    - Once the tests were completed the test environment was reset and the gateway restarted for future testing.
6. Bug found in SAML Header - A bug was discovered during the preparation for the style-sheet testing with the VA. The bug is a minor logical error in a fix that was implemented for the prefix in the SAML header.
    - The issue was resolved and patch was installed in both test and production. Required a brief down time for the server restart.
7. 2011 versus 2010 Specification Support- Verified and explained to Conemaugh how the CONNECT 3.3 gateway and the Conemaugh installation are set up to support 2011 specifications (which the VA has migrated to) as well as multi-version specification support.

8. CMIDHT-36 – Conemaugh work this month focused on addressing the final remaining formatting and discrepancy issues and move style sheet fixes for C-CDA clinical document display in Conemaugh Production environment.
    - Worked to understand some issues the VA was having with their updated C-CDA style sheet, how those changes impacted Conemaugh and coordinate the timing of the updates as they addressed these issues.
    - After migrating updated style sheet into production, researched issues found in the following sections:
        - Overall - formatting of the date fields
        - Lab Results
        - Immunizations
        - Plan of Care
    - Determined the cause and level of effort for the issues and found some of the issues would require larger than expected work. Discussed and provided more explanation and details for Conemaugh to make a determination.
    - Proceeded to address some of the issues per direction from Conemaugh, during this time Conemaugh also received and updated C-CDA which seemed to address some of the discrepancies originally being detached.
    - Until further solidifying of the style-sheet and C-CDA from the VA, no additional work was done without guidance from Conemaugh.
9. CMIDHT-39 – Conemaugh noticed a Universal Client issue in production, there was an issue with the list boxes for the Patient Discovery and Documents tab.
    - Since this was production issue support was somewhat limited due to access and potential impacts to production. Conemaugh supplied screen shots and results from analyzing the log files.
    - Performed a detailed analysis of the information provided and determined that the UDDI seemed to be populated incorrectly and could see business entries for different organizations.
    - This was a similar issue seen before with Glassfish 2.1.1 at startup. Request was made for the Production server to be re-started to see if this would clear the suspected GlassFish issues and resolve the original problem seen in the UC.
    - After the Production server was restarted the issue resolved, once Conemaugh validated this outcome the ticket was closed.
10. CMIDHT-41 – After reviewing the audit log Conemaugh noticed no activity from June 3-8, 2015 and June 11-25, 2015 but saw activity on June 26, 2015.
    - After researching it was determined that on the Production server the Glassfish application server was running out of memory showing there were 0 bytes free.

**Appendix I. NwHIN Conditional Acceptance**.



**John Hargreaves**

**From:** Yeager, Mariann (OS/ONC) (CTR) [Mariann.Yeager@hhs.gov]
**Sent:** Tuesday, September 27, 2011 3:12 PM
**To:** Joe Dado; John Hargreaves
**Cc:** Michael Matthews; vijay.shah@nitorgroup.com; vroberts@nationalehealth.org
**Subject:** Exchange Conditional Acceptance

Dear Joseph and John:

On September 26, 2011, the Exchange Coordinating Committee reviewed the validation testing results for Conemaugh Health System ("Conemaugh"). Based upon this information, we are pleased to notify you that Conemaugh has been conditionally accepted as a Participant in the Exchange.

This conditional acceptance requires that Conemaugh be ready to begin exchanging data in production using the validated services with another Exchange Participant no later than January 24, 2012. This is one hundred twenty (120) calendar days following the Coordinating Committee's conditional acceptance of your validation testing results.

As the Coordinating Committee Chair and on behalf of the Participants in the Exchange, I will countersign Conemaugh's DURSA Joinder Agreement, to take effect on the date you go into production as an Exchange Participant.

Please note that once the amended DURSA takes effect, Conemaugh will be required to sign the amended version. We will contact you with more details as the approval process progresses.

If, for any reason, Conemaugh is unable to go into production as an Exchange Participant by January 24, 2012, please notify your assigned ONC On Boarding Team representative and submit an extension request to the Coordinating Committee at onc.exchangeinfo@hhs.gov. The Coordinating Committee may accept or deny this extension request in accordance with its operating policies and procedures.

Conemaugh's formal acceptance as a Participant takes effect on the date Conemaugh's system is operational in a production environment, able to exchange data with other Participants, Conemaugh's DURSA Joinder Agreement is fully executed, and when Conemaugh's Digital Credentials are issued and Conemaugh is added to the Exchange service registry.

We do ask that you withhold announcements about your participation until your Participation goes into effect.

The following outlines next steps:

- An on boarding team representative will issue Conemaugh its Production Digital Credentials once the outstanding issue is addressed and verified by the on boarding team.
- You will be asked to provide the on boarding team the required information to add Conemaugh to the Exchange service registry. The on boarding team will confirm that the information supplied is accurate by testing the information provided.
- The on boarding team will issue Conemaugh Digital Credentials in the production registry. At this point, Conemaugh becomes activated as a Participant in the Exchange, enabling other Participants to identify and begin exchanging health information with Conemaugh.

If you have any questions regarding this process, please do not hesitate to contact any of the individuals carbon copied on this letter.

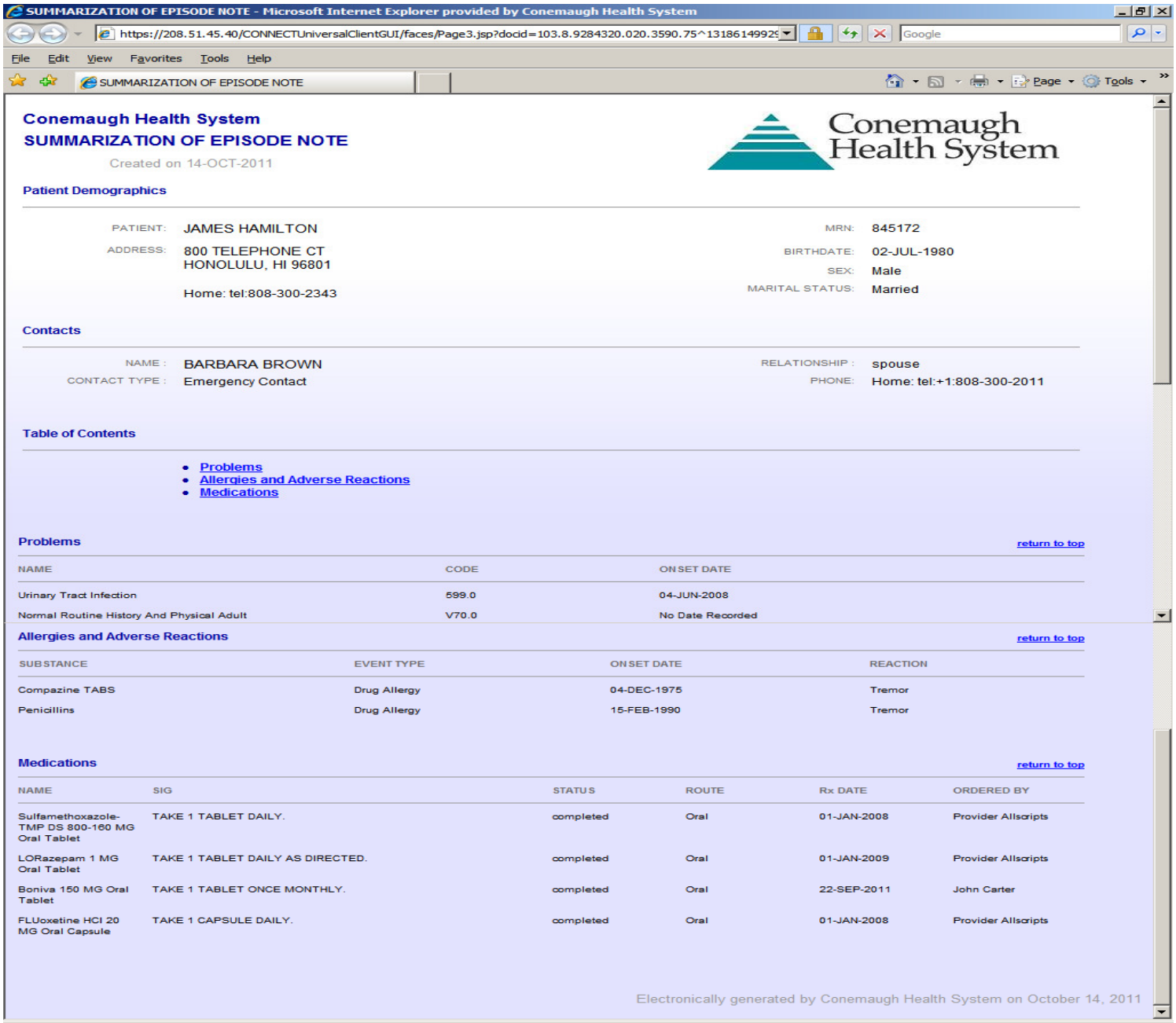
Regards,

Mariann Yeager (Coordinating Committee Secretary) on behalf of:

Michael Matthews
Chair, Exchange Coordinating Committee

9/27/2011

**Appendix J. Continuity of Care Document (C32).**



SUMMARIZATION OF EPISODE NOTE - Microsoft Internet Explorer provided by Conemaugh Health System

https://208.51.45.40/CONNECTUniversalClientGUI/faces/Page3.jsp?docid=103.8.9284320.020.3590.75^1318614992

File Edit View Favorites Tools Help

SUMMARIZATION OF EPISODE NOTE

Page Tools

## Conemaugh Health System
## SUMMARIZATION OF EPISODE NOTE

Created on 14-OCT-2011

Conemaugh Health System

### Patient Demographics

| | | | |
|---|---|---|---|
| PATIENT: | JAMES HAMILTON | MRN: | 845172 |
| ADDRESS: | 800 TELEPHONE CT<br>HONOLULU, HI 96801<br><br>Home: tel:808-300-2343 | BIRTHDATE:<br>SEX:<br>MARITAL STATUS: | 02-JUL-1980<br>Male<br>Married |

### Contacts

| | | | |
|---|---|---|---|
| NAME : | BARBARA BROWN | RELATIONSHIP : | spouse |
| CONTACT TYPE : | Emergency Contact | PHONE: | Home: tel:+1:808-300-2011 |

### Table of Contents



### Problems

return to top

| NAME | CODE | ONSET DATE |
|---|---|---|
| Urinary Tract Infection | 599.0 | 04-JUN-2008 |
| Normal Routine History And Physical Adult | V70.0 | No Date Recorded |

### Allergies and Adverse Reactions

return to top

| SUBSTANCE | EVENT TYPE | ONSET DATE | REACTION |
|---|---|---|---|
| Compazine TABS | Drug Allergy | 04-DEC-1975 | Tremor |
| Penicillins | Drug Allergy | 15-FEB-1990 | Tremor |

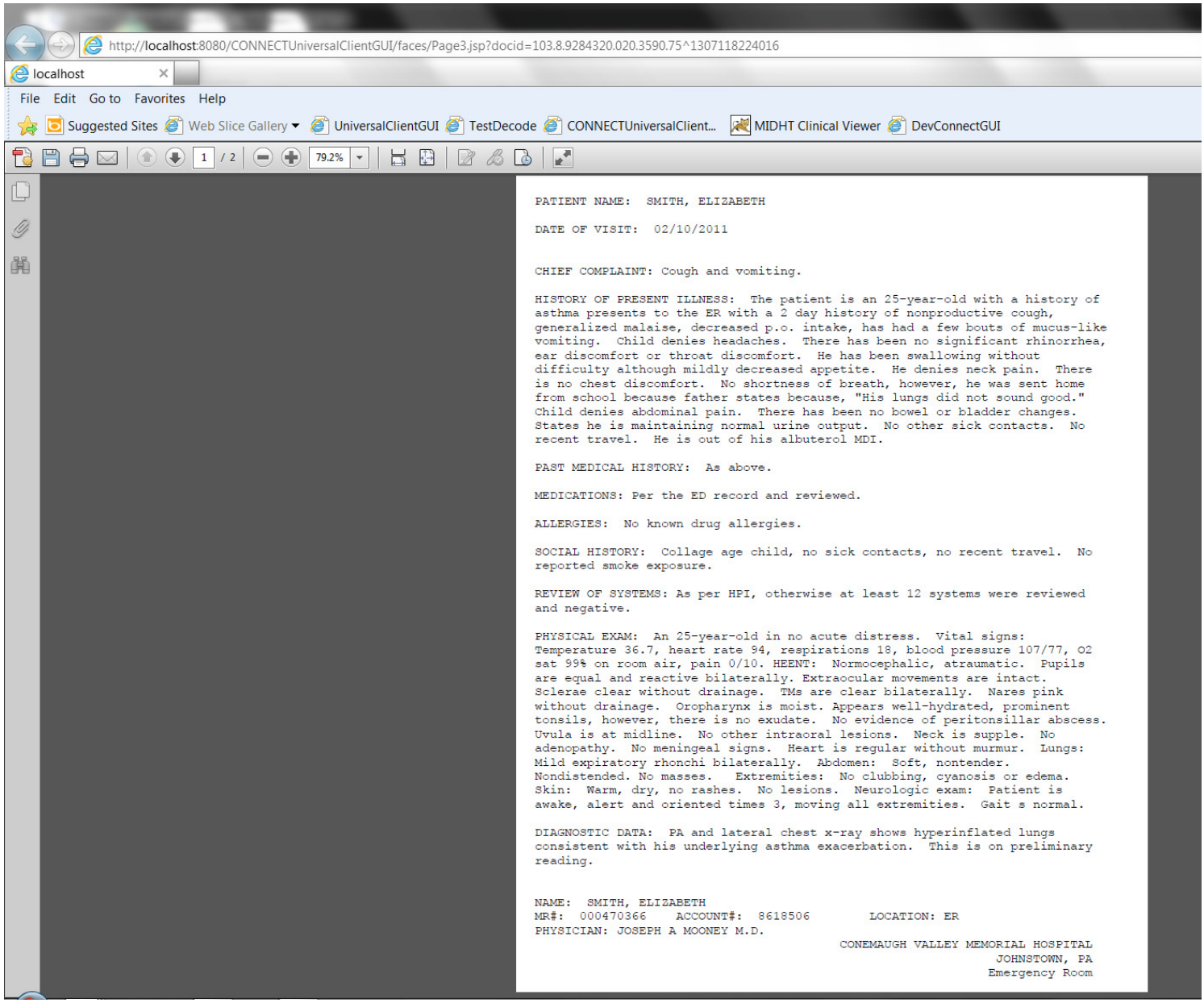
### Medications

return to top

| NAME | SIG | STATUS | ROUTE | Rx DATE | ORDERED BY |
|---|---|---|---|---|---|
| Sulfamethoxazole-TMP DS 800-160 MG Oral Tablet | TAKE 1 TABLET DAILY. | completed | Oral | 01-JAN-2008 | Provider Allscripts |
| LORazepam 1 MG Oral Tablet | TAKE 1 TABLET DAILY AS DIRECTED. | completed | Oral | 01-JAN-2009 | Provider Allscripts |
| Boniva 150 MG Oral Tablet | TAKE 1 TABLET ONCE MONTHLY. | completed | Oral | 22-SEP-2011 | John Carter |
| FLUoxetine HCl 20 MG Oral Capsule | TAKE 1 CAPSULE DAILY. | completed | Oral | 01-JAN-2008 | Provider Allscripts |

Electronically generated by Conemaugh Health System on October 14, 2011

**Appendix K. Emergency Room Discharge Summary (C62).**



**Appendix L. VLER Joint Patient Letter.**


James E. Van Zandt
VA Medical Center

Dear Veteran,

There is a new way to share information with your healthcare providers in southwestern Pennsylvania!

The Virtual Lifetime Electronic Record (VLER) health program will allow you to share your electronic health information, via the Nationwide Health Information Network (NwHIN), with your providers who are members of the Conemaugh Health System and the James E. Van Zandt VA Medical Center in Altoona, PA.

We invite you to sign up for the VLER Health program by completing and signing the enclosed forms. After you join, your health care providers will be able to see your current medical issues, emergency room reports, discharge summaries, medications, allergies, and other important information in your medical record as necessary for your treatment. This information will be used to improve the care you receive from your providers, and avoid duplicating services. Access to your information will be strictly controlled and protected using data security standards commonly used in the banking industry.

Once you have completed and signed the forms we have included, please return them in the envelope provided. Signing these forms means that you are agreeing to share your health information among health care providers in the NwHIN Exchange who provide your medical treatment.

If you have questions, please contact:
John Hargreaves, Conemaugh Health System, at (814) 269-5277, and/or
Barbara Babiak, VLER Coordinator, James E. Van Zandt VA Medical Center, at (814) 943-8164 Ext. 8022.

We are proud to serve Veterans that served our country!

Scott Becker
Chief Executive Officer
Conemaugh Health System

William Mills
Medical Center Director
James E. Van Zandt VA Medical Center

*If you decide not to join, do nothing. Your health record will not be shared with private healthcare facilities using this program. Your choice will not affect the care you receive from your providers, your future care at the VA, or your VA benefits. If you choose to join now and later change your mind, please contact the VA Release of Information Office at (814) 943-8164 Ext. 8022.*

**Appendix M. Conemaugh Consent Form.**

Conemaugh Health System

Request for and Consent to Release Protected Health Information to the eHealth Exchange

Privacy Act Information: By completing this form, no release of information will occur other than that stated below. The form allows for the release of information in accordance with the Health Insurance Portability and Accountability Act (HIPAA), 45 CFR Parts 160/164 and 5 U.S.C. 552a. Your consent to release the information on this form is voluntary. If the information containing the last four digits of your Social Security Number (SSN) is not accurate, the eHealth Exchange will be unable to comply with the request. The SSN will be used to locate records for release. The Conemaugh Health System (CHS) may not condition treatment or other actions on signing of this consent. CHS may release the information you put on this form as allowed by law. CHS may make "routine use" disclosure of the information as stated in the CHS "Notice of Privacy Practices". Failure to participate will not have any affect on care to which you may receive. CHS may also use this information on this form to identify patients and their records. Other purposes involving this information may occur as allowed by law.

**Name:** _____

**Last 4 digits of SSN:** _____

**Date of Birth:** _____

**Requestor Name:** Approved eHealth Exchange Participants

**Information Requested:**

Health information from electronic health record systems.

I permit CHS to release my protected health information (PHI) for treatment purposes to those communities that are participating in the eHealth Exchange. As covered by 38 U.S.C. 7332, this information may consist of:

- Diagnosis of Sickle Cell Anemia
- Treatment of or referral for drug abuse
- Treatment of or referral for alcohol abuse
- Treatment of or testing for HIV/AIDS

This consent covers conditions that I may have upon signing of the consent. It also covers conditions that I may acquire in the future. This consent will remain in effect for five years. I may withdraw this consent, in writing, at any time. I understand that actions may already have been taken to comply with it. Written withdrawal is effective upon receipt by CHS. Redisclosure of my electronic health records by others may occur without my further written consent. Redisclosure by others may also no longer be protected.

**CONSENT:** I certify that this request has been made freely and without force. The information given above is accurate and complete to the best of my knowledge.

_____ _____

**Patient Signature** **Date**

**Appendix N. Health Information Exchange FAQs Flyer.**

CONEMAUGH HEALTH SYSTEM

# Health Information Exchange FAQ's

## Make your electronic medical records available to your providers.

Conemaugh Health System is pleased to introduce sharing of health records through the Nationwide Health Information Network (NwHIN). The goal of the project is to securely exchange electronic medical records and patient data with external organizations, including the Altoona VA Medical Center, to provide veterans timely and accurate healthcare services.

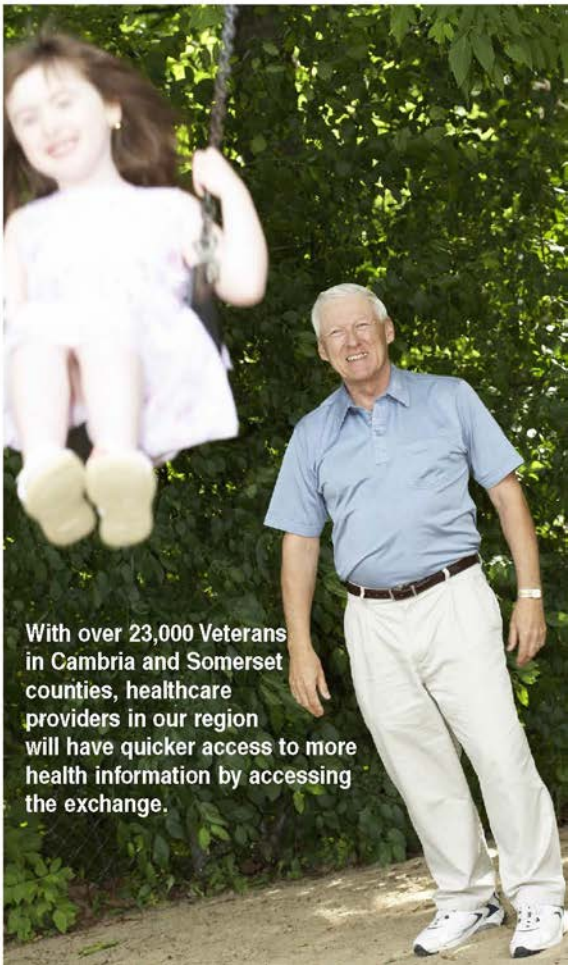
### How Does It Benefit Me?

Veterans may receive some of their care from non-VA care providers. Electronic medical record sharing allows additional providers to access secure, updated health information to provide you accurate and timely care. Electronic files also eliminate the need for you to carry your confidential medical records between providers.

### Is my information secure?

Conformance testing to ensure compliance with messaging, privacy and security specifications at Conemaugh Health System was completed with the Office of the National Coordinator for Health Information Technology, part of the Department of Health and Human Services. The information is sent securely through the Nationwide Health Information Network. Only healthcare providers that are participating in the exchange will be able to view your records with the strict purpose of providing direct patient care.

EXCELLENCE. EVERY PATIENT. EVERY TIME.



CONEMAUGH HEALTH SYSTEM

**Shared Information includes:**

- Continuity of Care (meds, problems, allergies)
- Emergency Room Reports
- Lab Results
- Radiology Reports
- Discharge Summaries

**I Only See One Provider. Should I still Join?**

Unfortunately, unforeseen accidents and emergencies occur. When they do, Conemaugh Health System services may be the closest available. Providing additional health information to health care entities in our network can help save your life in an emergency.

**How Do I Participate?**

Participation in this program is voluntary and free. Signing up is fast and easy! Request a form from your primary care provider or call 814-269-5277. Mail form to John Hargreaves, Conemaugh East Hills, 1450 Scalp Avenue, Suite 120, Johnstown, PA 15904

**What If I Decide Not To Join?**

Participation in this program is strictly voluntary. Your decision not participate will not impact the quality care you receive through the Conemaugh Health System.

Conemaugh Health System

**Appendix O. MIDHT Press Release.**



# Conemaugh Health System one of first hospitals to join Nationwide Health Information Network (NwHIN)



Posted: 2012-09-11

The Conemaugh Health System is the first Pennsylvania non-government health care system and one of just 30 in the United States to go "LIVE" on the Nationwide Health Information Network (NwHIN) Exchange. The NwHIN Exchange is sponsored by the federal government's Office of the National Coordinator as a way to securely share health information over the Internet – aka Health Information Exchange.

The Conemaugh Health System, comprised of Conemaugh Memorial Medical Center, Conemaugh Miners Medical Center, Conemaugh Meyersdale Medical Center, and the Conemaugh Physician Group has attained NwHIN Exchange operational status as part of the Military Interoperable Digital Hospital Testbed (MIDHT), a research and development pilot project designed to promote secure health information sharing between government and private sector healthcare systems.

The goal of the project at Conemaugh is to securely exchange electronic medical records and patient data with external organizations, including the James E. Van Zandt VA Medical Center in Altoona through the Virtual Lifetime Electronic Record (VLER) pilot program. With over 3,000 veterans seeking care from both organizations, clinicians will have on line access to more health information by accessing the "NwHIN Exchange." Conemaugh will provide continuity of care records, hospital discharge summaries and radiology reports to partners in order to improve care coordination, enhance decision making and reduce duplicate testing. Shared patients will be contacted via postal mail in the coming weeks to enroll into the program.

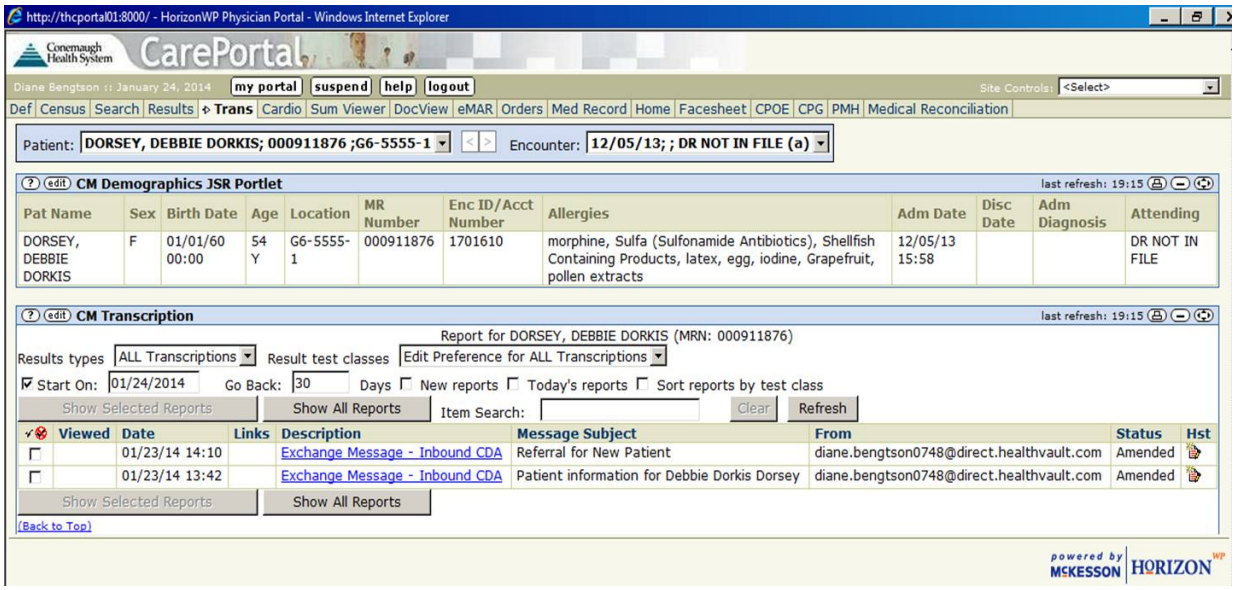
"We are excited to participate in the VLER program, the first in the state of Pennsylvania. I encourage veterans to complete both consent forms and hope providers utilize the "Exchange" to improve care in our region," said John S. Hargreaves, MIDHT Project Manager.

Conformance testing to ensure compliance with messaging, privacy and security specifications was completed with the Office of the National Coordinator for Health Information Technology, part of the Department of Health and Human Services. After review, Conemaugh was accepted as a Participant in the "NwHIN Exchange".

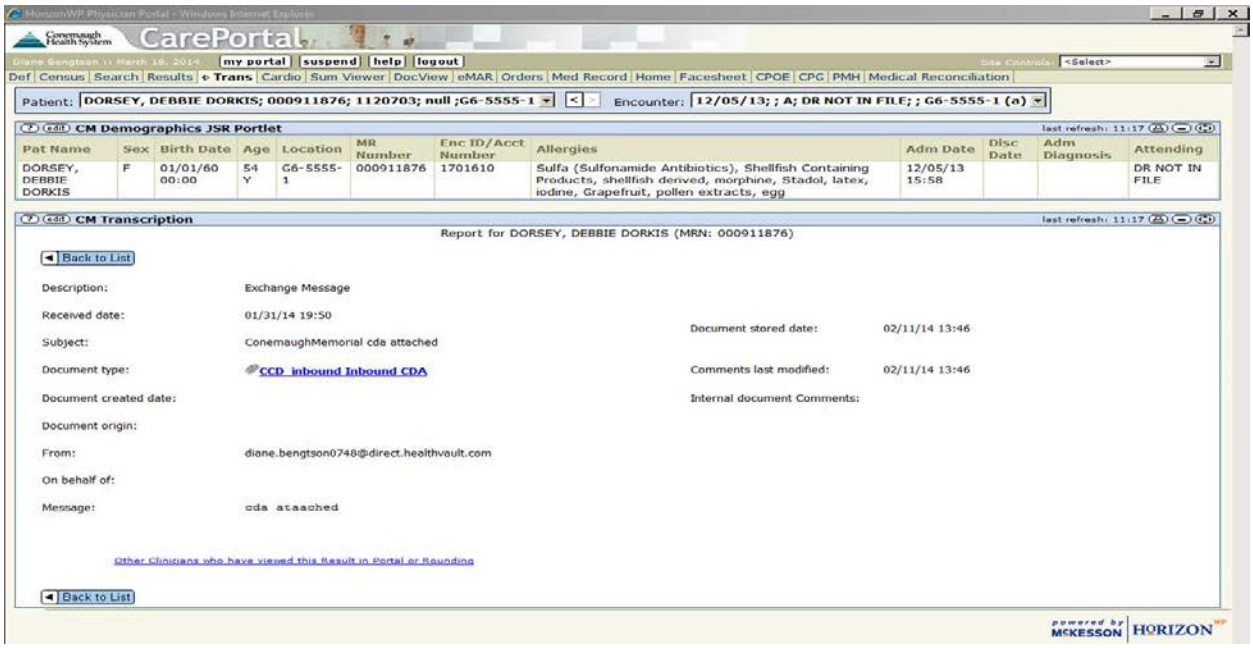
The MIDHT project is sponsored by the U.S. Army Medical Research & Materiel Command's (USAMRMC) Telemedicine & Advanced Technology Research Center (TATRC) and is funded by the Department of Defense through Contract # W81XWH-10-2-0180. Northrop Grumman Corporation is a subcontractor to this

**Appendix P. CDA Inbound Documentation Instructions.**

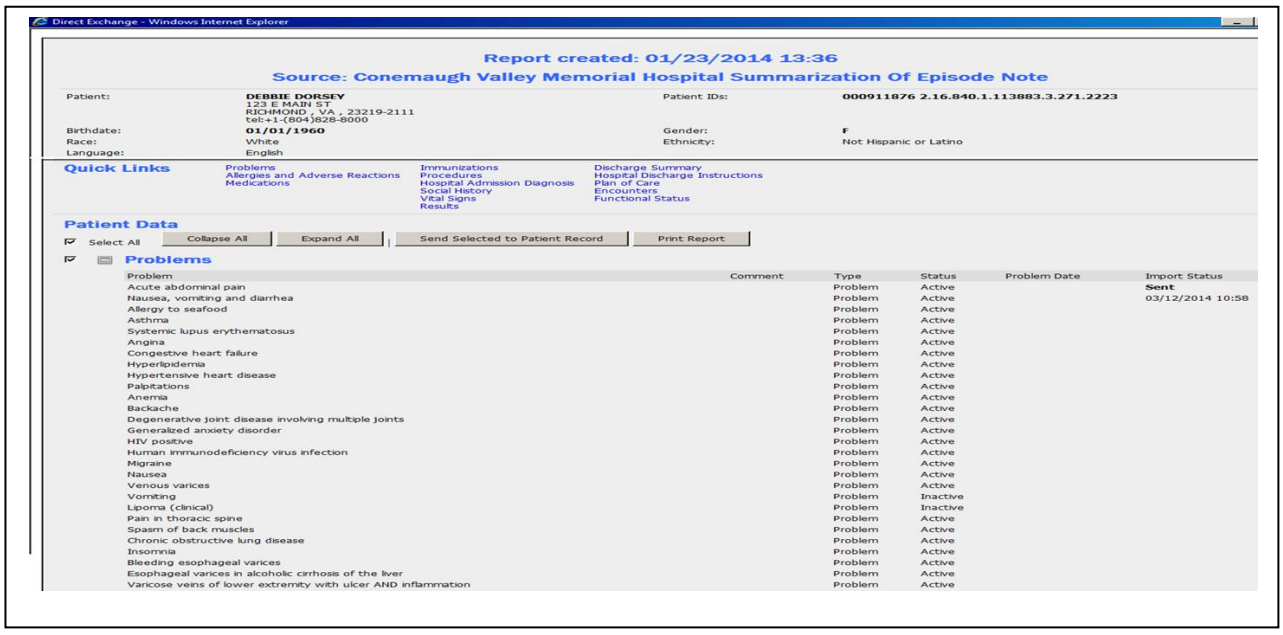
## 1. Inbound message is displayed in CarePortal.




## 2. The link is then selected to view the message.



3. **The "CCD Inbound CDA" is selected to open the attachment to view the patient record**.

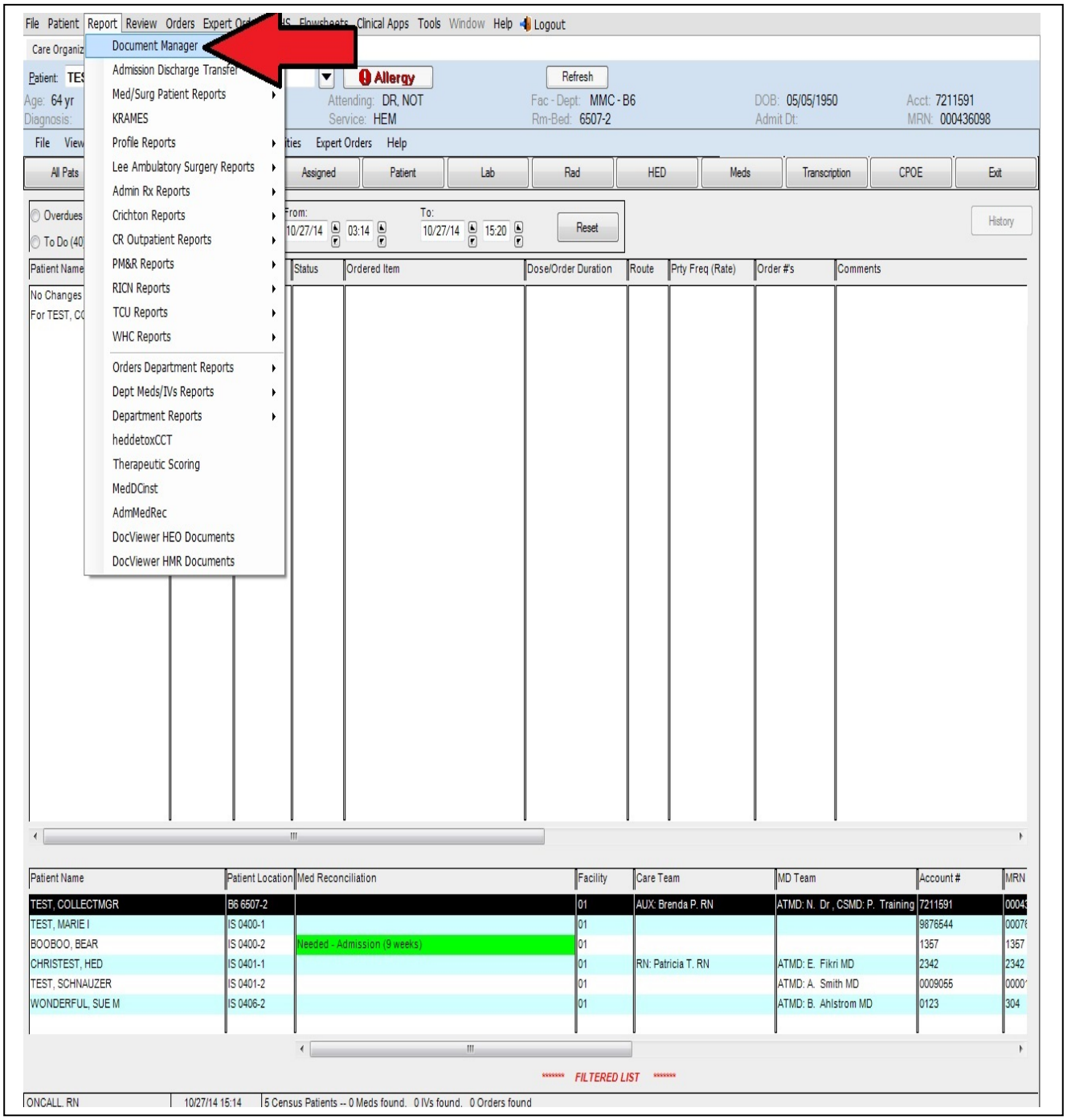


**Appendix Q. CCDA Outbound Documentation Instructions.**

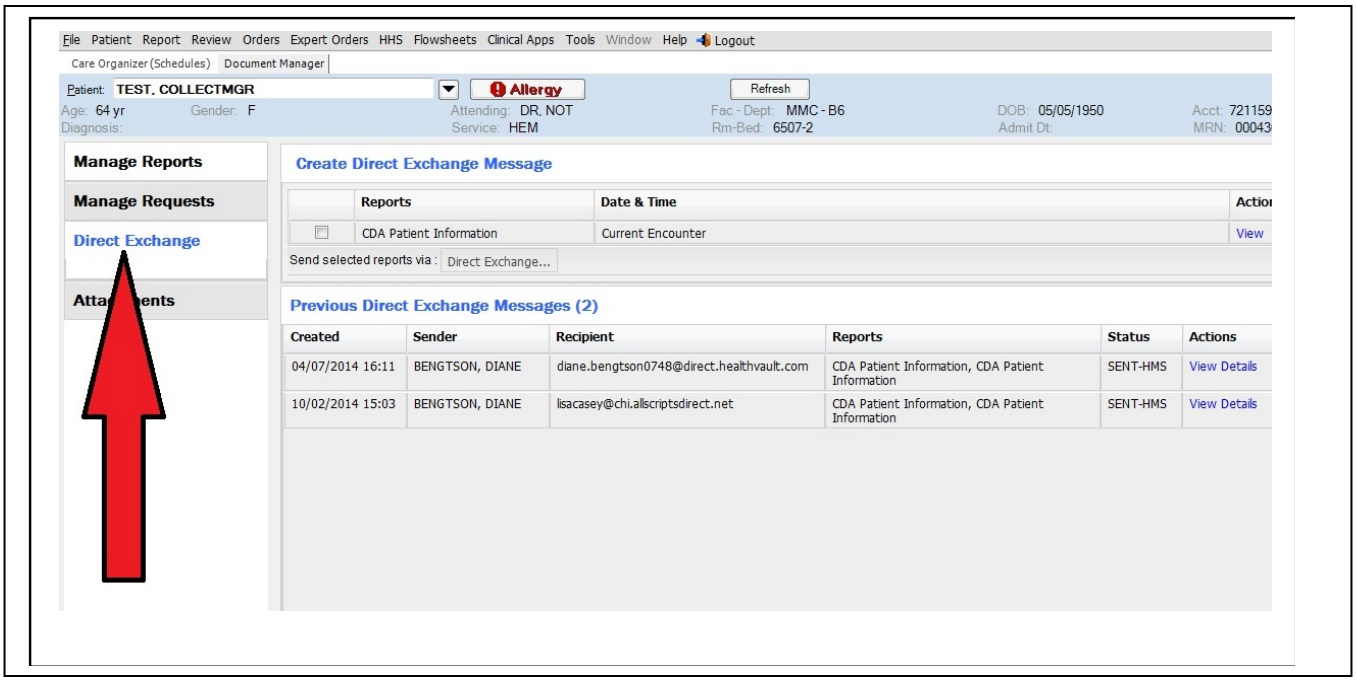
1. **Login to Care Manager.**

2. **Click on the Report Link.**

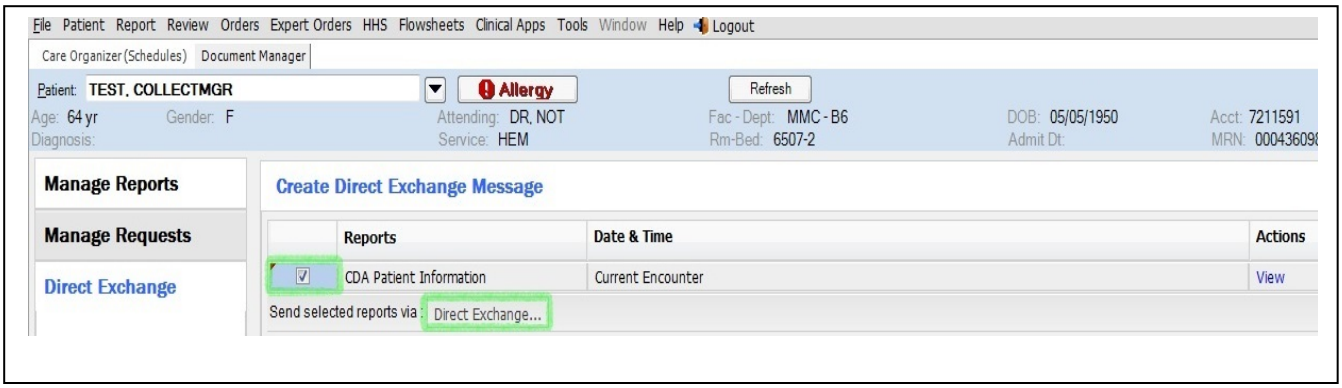
3. **Click on Document Manager.**



4. **Click on the Direct Exchange Link.**

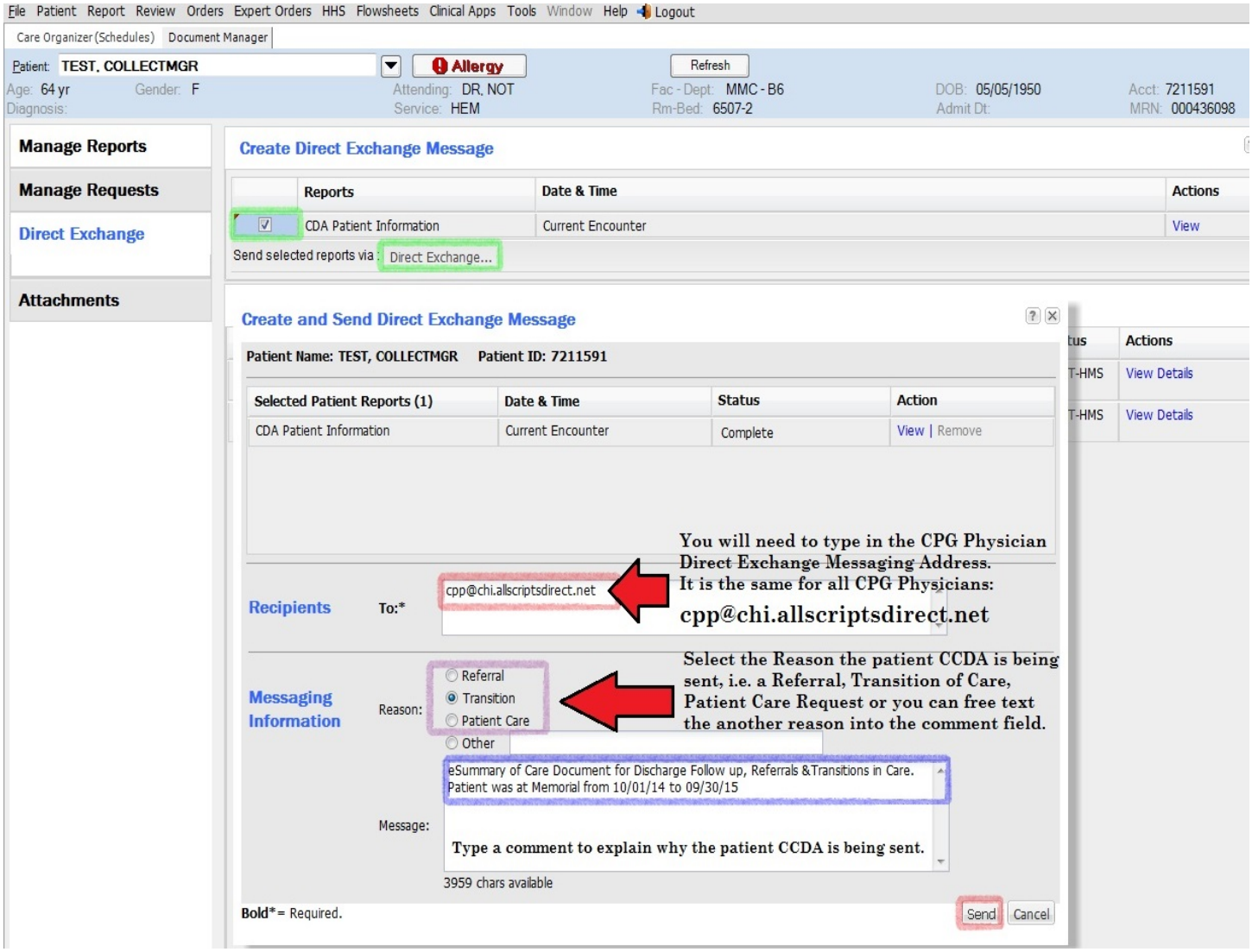



5. **Click the checkbox next to the CCDA Patient Information and then click on the Direct Exchange Tab below the checkbox**




6. **Type in the Direct Exchange Address for the Recipient To: field**
   a. If the patient is being referred or transitioned to PCRC then type: cpp@chi.allscriptsdirect.net
   b. If the patient is being referred or transitioned to Memorial then type: Memorial@direct.relayhealth.com
   c. If the patient is being referred or transitioned to Miners then type: Miners@direct.relayhealth.com

d. If the patient is being referred or transitioned to Meyersdale then type: Meyersdale@direct.relayhealth.com
e. If the patient is being referred or transitioned to Home Health then type: ConemaughHH@healthpoint.medicity.net
f. If the patient is being referred or transitioned to a CPG Provider then type: cpp@chi.allscriptsdirect.net
g. If the patient is requesting a personal copy of their CCDA and is a Follow My Health Member then type: followmyhealth@fmh.allscriptsdirect.net




**7. Click the corresponding radio button for the Reason the CCDA is being sent.**

a. Referral to another Service Provider such as PCRC or Home Health
b. Transitioned to another setting of care, i.e. Crichton, CPG Primary Care Provider, etc.
c. Patient Care- such as Hospice

d. Other- Requires a Reference Reason be typed in corresponding box

**8. Type the rational for the CCDA being sent into the Message Field for example:**

a. eSummary of Care Document for Referrals and Transitions in Care.
   Patient was at Memorial from 10/21/14 to 10/29/14
b. eSummary of Care Document for Referrals and Transitions in Care.
   Patient was at Miners from 10/12/14 to 10/17/14
c. eSummary of Care Document for Referrals and Transitions in Care.
   Patient was at Meyersdale from 10/14/14 to 10/16/14
d. eSummary of Care Document for Admission Referral to PCRC.
   Patient was admitted at Memorial 10/28/2014
e. eSummary of Care Document for Referrals and Transitions in Care-Home Health.
   Patient was at Memorial from 10/12/14 to 10/17/14

**9. Click the send tab.**

**Appendix R. Cross tabulations of VLER Patient Survey**

**Case Processing Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Valid | | Missing | | Total | |
| | N | Percent | N | Percent | N | Percent |
| Did you feel your health information was secure and private? * Did your providers talk about the new service during your appointments? | **112** | **94.1%** | **7** | **5.9%** | **119** | **100.0%** |
| Gender: * Did your providers talk about the new service during your appointments? | **113** | **95.0%** | **6** | **5.0%** | **119** | **100.0%** |

**Crosstab**

| | | | Did your providers talk about the new service during your appointments? | | |
|---|---|---|---|---|---|
| | | | YES | NO | Total |
| Did you feel your health information was secure and private? | YES | Count | **$42_a$** | **$39_b$** | **81** |
| | | % within Did you feel your health information was secure and private? | **51.9%** | **48.1%** | **100.0%** |
| | | % within Did your providers talk about the new service during your appointments? | **85.7%** | **61.9%** | **72.3%** |
| | | % of Total | **37.5%** | **34.8%** | **72.3%** |
| | | Std. Residual | **1.1** | **-1.0** | |
| | NO or Not Sure | Count | **$7_a$** | **$24_b$** | **31** |
| | | % within Did you feel your health information was secure and private? | **22.6%** | **77.4%** | **100.0%** |
| | | % within Did your providers talk about the new service during your appointments? | **14.3%** | **38.1%** | **27.7%** |
| | | % of Total | **6.3%** | **21.4%** | **27.7%** |
| | | Std. Residual | **-1.8** | **1.6** | |
| Total | | Count | **49** | **63** | **112** |
| | | % within Did you feel your health information was secure and private? | **43.8%** | **56.3%** | **100.0%** |
| | | % within Did your providers talk about the new service during your appointments? | **100.0%** | **100.0%** | **100.0%** |
| | | % of Total | **43.8%** | **56.3%** | **100.0%** |

Each subscript letter denotes a subset of Did your providers talk about the new service during your appointments? categories whose column proportions do not differ significantly from each other at the .05 level.

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) | Exact Sig. (2-sided) | Exact Sig. (1-sided) |
|---|---|---|---|---|---|
| Pearson Chi-Square | **7.806**[a] | **1** | **.005** | | |
| Continuity Correction[b] | **6.662** | **1** | **.010** | | |
| Fisher's Exact Test | | | | **.006** | **.004** |
| N of Valid Cases | **112** | | | | |

**Risk Estimate**

| | Value | 95% Confidence Interval Lower | Upper |
|---|---|---|---|
| Odds Ratio for Did you feel your health information was secure and private? (YES / NO or Not Sure) | **3.692** | **1.431** | **9.529** |
| For cohort Did your providers talk about the new service during your appointments? = YES | **2.296** | **1.158** | **4.554** |
| For cohort Did your providers talk about the new service during your appointments? = NO | **.622** | **.463** | **.836** |
| N of Valid Cases | **112** | | |

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 13.56.

b. Computed only for a 2x2 table

**Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. * Did your providers talk about the new service during your appointments? Crosstabulation**

| | | | Did your providers talk about the new service during your appointments? YES | NO | Total |
|---|---|---|---|---|---|
| Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | Better Coordination of Care | Count | **$41_a$** | **$37_a$** | **78** |
| | | % within Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | **52.6%** | **47.4%** | **100.0%** |

Each subscript letter denotes a subset of Did your providers talk about the new service during your appointments? categories whose column proportions do not differ significantly from each other at the .05 level.

**Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. * Did your providers talk about the new service during your appointments? Crosstabulation**

| | | | Did your providers talk about the new service during your appointments? YES | NO | Total |
|---|---|---|---|---|---|
| Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | Improved Patient Safety | Count | **$28_a$** | **$22_a$** | **50** |
| | | % within Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | **56.0%** | **44.0%** | **100.0%** |

Each subscript letter denotes a subset of Did your providers talk about the new service during your appointments? categories whose column proportions do not differ significantly from each other at the .05 level.

**Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. * Did your providers talk about the new service during your appointments? Crosstabulation**

| | | | Did your providers talk about the new service during your appointments? | | |
|---|---|---|---|---|---|
| | | | YES | NO | Total |
| Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | Improved Decision Making/Quality of Care | Count | **29$_a$** | **30$_a$** | **59** |
| | | % within Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | **49.2%** | **50.8%** | **100.0%** |

Each subscript letter denotes a subset of Did your providers talk about the new service during your appointments? categories whose column proportions do not differ significantly from each other at the .05 level.

**Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. * Did your providers talk about the new service during your appointments? Crosstabulation**

| | | | Did your providers talk about the new service during your appointments? | | |
|---|---|---|---|---|---|
| | | | YES | NO | Total |
| Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | Less Duplicate Testing | Count | **34$_a$** | **33$_a$** | **67** |
| | | % within Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | **50.7%** | **49.3%** | **100.0%** |

Each subscript letter denotes a subset of Did your providers talk about the new service during your appointments? categories whose column proportions do not differ significantly from each other at the .05 level.

**Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. * Did your providers talk about the new service during your appointments? Crosstabulation**

| | | | Did your providers talk about the new service during your appointments? | | |
|---|---|---|---|---|---|
| | | | YES | NO | Total |
| Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | Reduced the Need to Hand Carry Records | Count | **32$_a$** | **34$_a$** | **66** |
| | | % within Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | **48.5%** | **51.5%** | **100.0%** |

Each subscript letter denotes a subset of Did your providers talk about the new service during your appointments? categories whose column proportions do not differ significantly from each other at the .05 level.

**Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. * Did your providers talk about the new service during your appointments? Crosstabulation**

| | | | Did your providers talk about the new service during your appointments? | | |
|---|---|---|---|---|---|
| | | | YES | NO | Total |
| Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | I am Not Sure | Count | **1$_a$** | **3$_a$** | **4** |
| | | % within Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | **25.0%** | **75.0%** | **100.0%** |

Each subscript letter denotes a subset of Did your providers talk about the new service during your appointments? categories whose column proportions do not differ significantly from each other at the .05 level.

**Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. * Did you feel your health information was secure and private? Crosstabulation**

| | | | Did you feel your health information was secure and private? | | |
|---|---|---|---|---|---|
| | | | YES | NO or Not Sure | Total |
| Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | Better Coordination of Care | Count | **66$_a$** | **14$_a$** | **80** |
| | | % within Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | **82.5%** | **17.5%** | **100.0%** |

Each subscript letter denotes a subset of Did you feel your health information was secure and private? categories whose column proportions do not differ significantly from each other at the .05 level.

**Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. * Did you feel your health information was secure and private? Crosstabulation**

| | | | Did you feel your health information was secure and private? | | |
|---|---|---|---|---|---|
| | | | YES | NO or Not Sure | Total |
| Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | Improved Patient Safety | Count | **41$_a$** | **10$_a$** | **51** |
| | | % within Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | **80.4%** | **19.6%** | **100.0%** |

Each subscript letter denotes a subset of Did you feel your health information was secure and private? categories whose column proportions do not differ significantly from each other at the .05 level.

**Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. * Did you feel your health information was secure and private? Crosstabulation**

| | | | Did you feel your health information was secure and private? | | |
|---|---|---|---|---|---|
| | | | YES | NO or Not Sure | Total |
| Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | Improved Decision Making/Quality of Care | Count | **49$_a$** | **12$_a$** | **61** |
| | | % within Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | **80.3%** | **19.7%** | **100.0%** |

Each subscript letter denotes a subset of Did you feel your health information was secure and private? categories whose column proportions do not differ significantly from each other at the .05 level.

**Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. * Did you feel your health information was secure and private? Crosstabulation**

| | | | Did you feel your health information was secure and private? | | |
|---|---|---|---|---|---|
| | | | YES | NO or Not Sure | Total |
| Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | Less Duplicate Testing | Count | **50$_a$** | **17$_a$** | **67** |
| | | % within Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | **74.6%** | **25.4%** | **100.0%** |

Each subscript letter denotes a subset of Did you feel your health information was secure and private? categories whose column proportions do not differ significantly from each other at the .05 level.

**Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. * Did you feel your health information was secure and private? Crosstabulation**

| | | | Did you feel your health information was secure and private? | | |
|---|---|---|---|---|---|
| | | | YES | NO or Not Sure | Total |
| Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | Reduced the Need to Hand Carry Records | Count | **$51_a$** | **$16_a$** | **67** |
| | | % within Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | **76.1%** | **23.9%** | **100.0%** |

Each subscript letter denotes a subset of Did you feel your health information was secure and private? categories whose column proportions do not differ significantly from each other at the .05 level.

**Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. * Did you feel your health information was secure and private? Crosstabulation**

| | | | Did you feel your health information was secure and private? | | |
|---|---|---|---|---|---|
| | | | YES | NO or Not Sure | Total |
| Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | I am Not Sure | Count | **$2_a$** | **$2_a$** | **4** |
| | | % within Please select which benefits you believe were achieved as a result of HIE between Conemaugh and Altoona VA. | **50.0%** | **50.0%** | **100.0%** |

Each subscript letter denotes a subset of Did you feel your health information was secure and private? categories whose column proportions do not differ significantly from each other at the .05 level.